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Nomura

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(54) **IMAGE FORMING APPARATUS**

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G03G 15/04 (2006.01)
G03G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/043*** (2013.01); ***G03G 15/04054*** (2013.01); ***G03G 15/5029*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/043; G03G 15/04054; G03G 15/5008; G03G 15/5029; G03G 2215/00738; G03G 2215/00742
See application file for complete search history.

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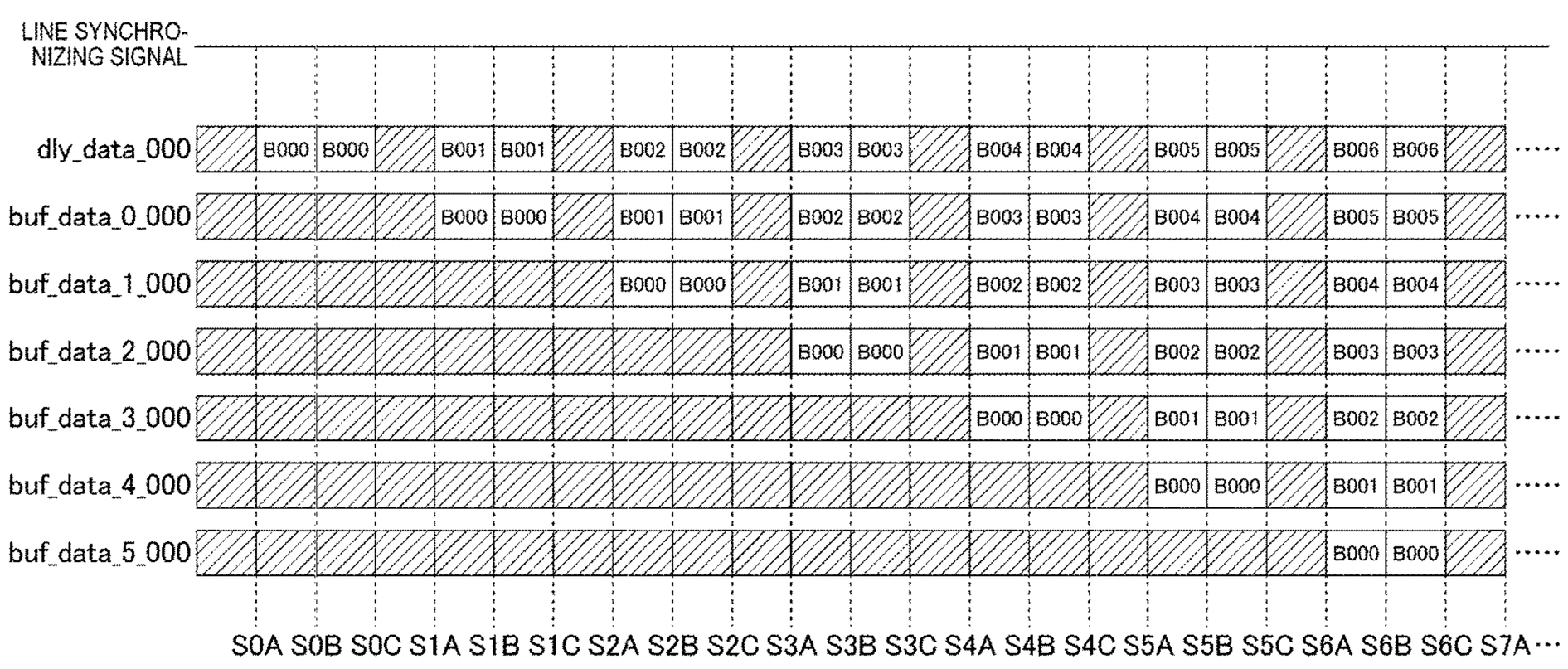
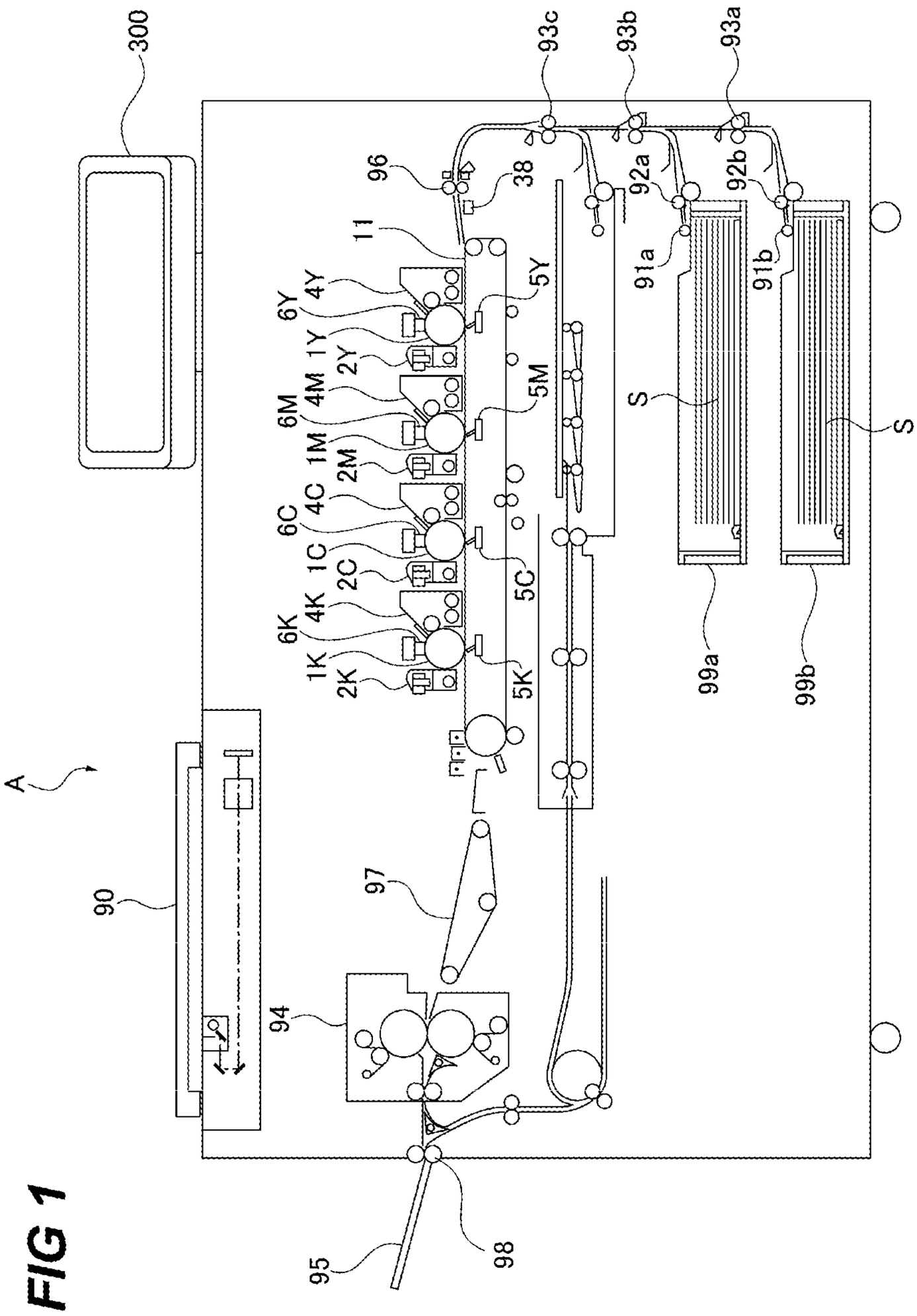
(57) **ABSTRACT**

In an image forming apparatus, a CPU can perform in a normal mode and a low mode in which a photoconductive drum rotates at a rate m/n times the rotational rate in the normal mode, and lower than the rotational rate in the normal mode. In the low mode, the CPU causes a synchronizing signal generation portion to generate a line synchronizing signal at a cycle 1/m times the cycle of the line synchronizing signal generated in the normal mode, and causes a chip data conversion portion to transmit, to an exposure head, the same image data signal m times and transmit, to the exposure head, an image data signal that brings a light-emitting portion into no light emission n-m times, in synchronization with n number of line synchronizing signals.

5 Claims, 16 Drawing Sheets

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93b
93a
96
38
11
92a
92b
5Y
6Y
4Y
1Y
2Y
91a
91b
6M
4M
1M
2M
5M
S
6C
4C
1C
2C
5C
6K
4K
1K
2K
5K
99a
99b
A
90
97
94
95
98

FIG 1

FIG 2A

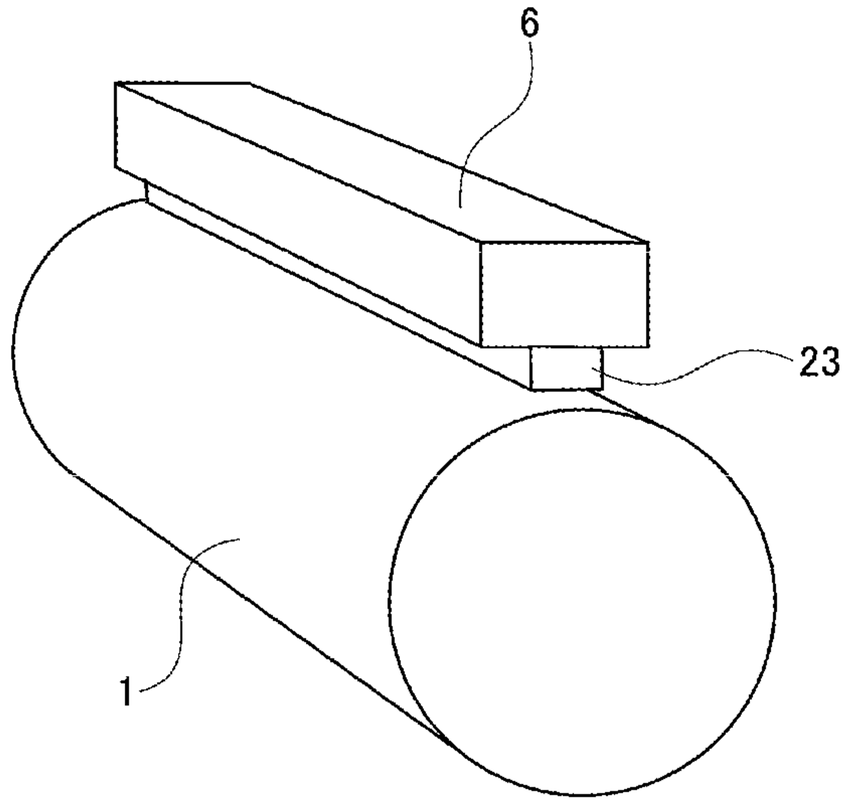


FIG 2B

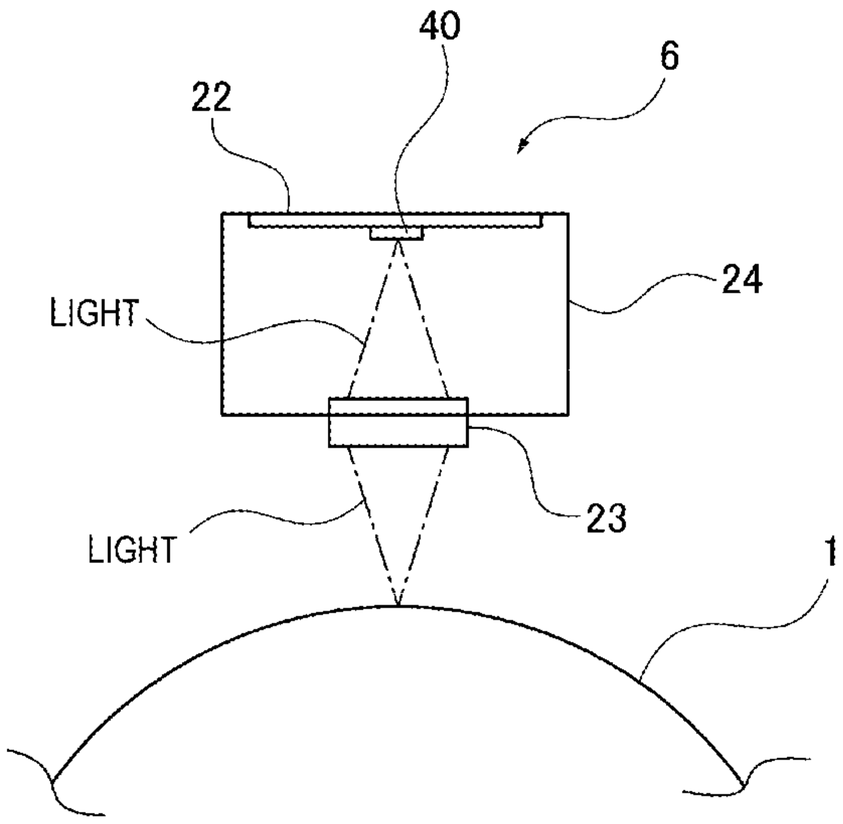


FIG 3A

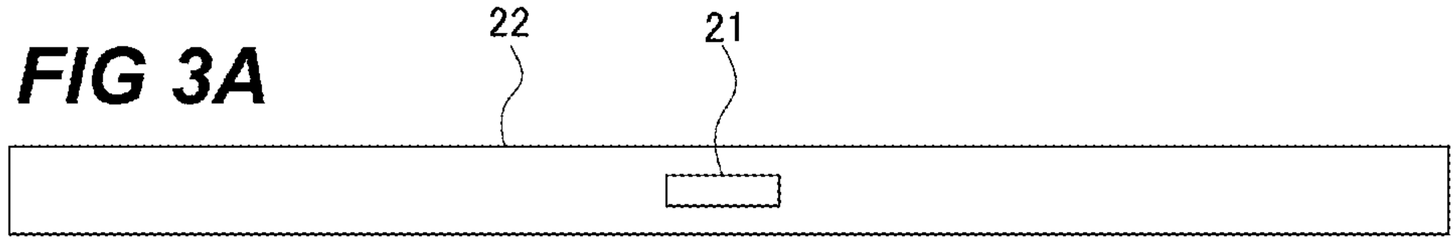


FIG 3B

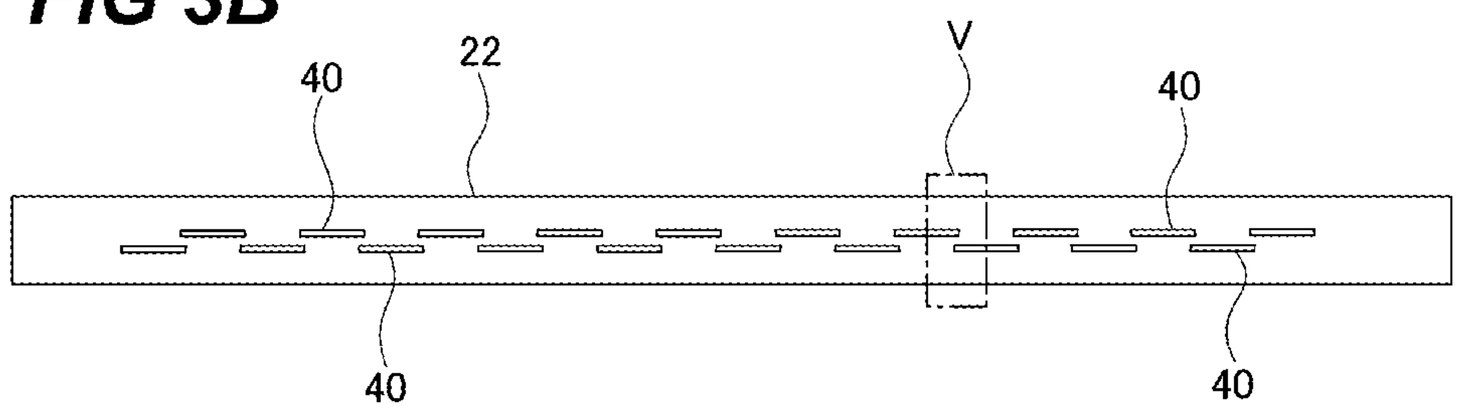


FIG 3C

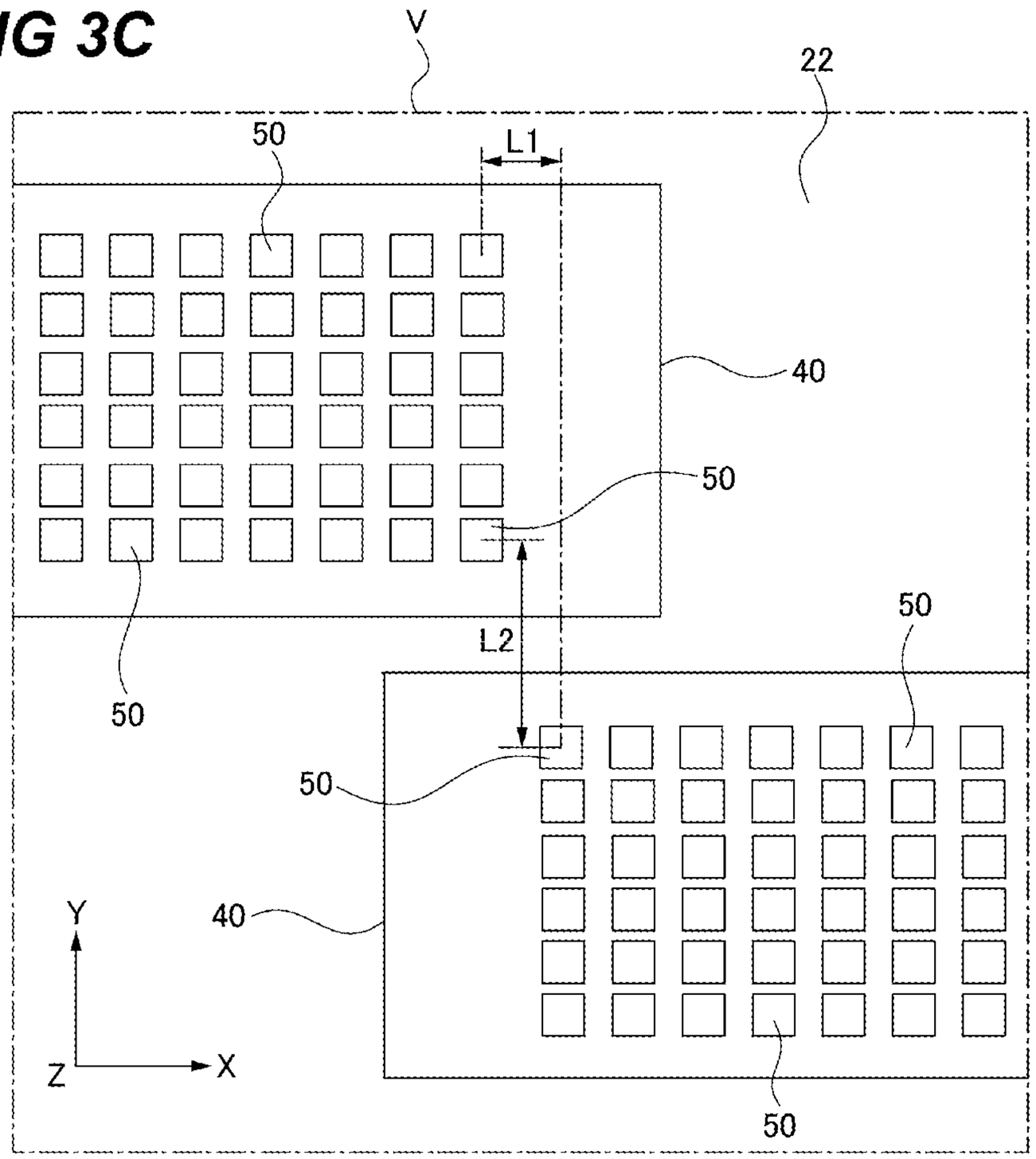


FIG 4

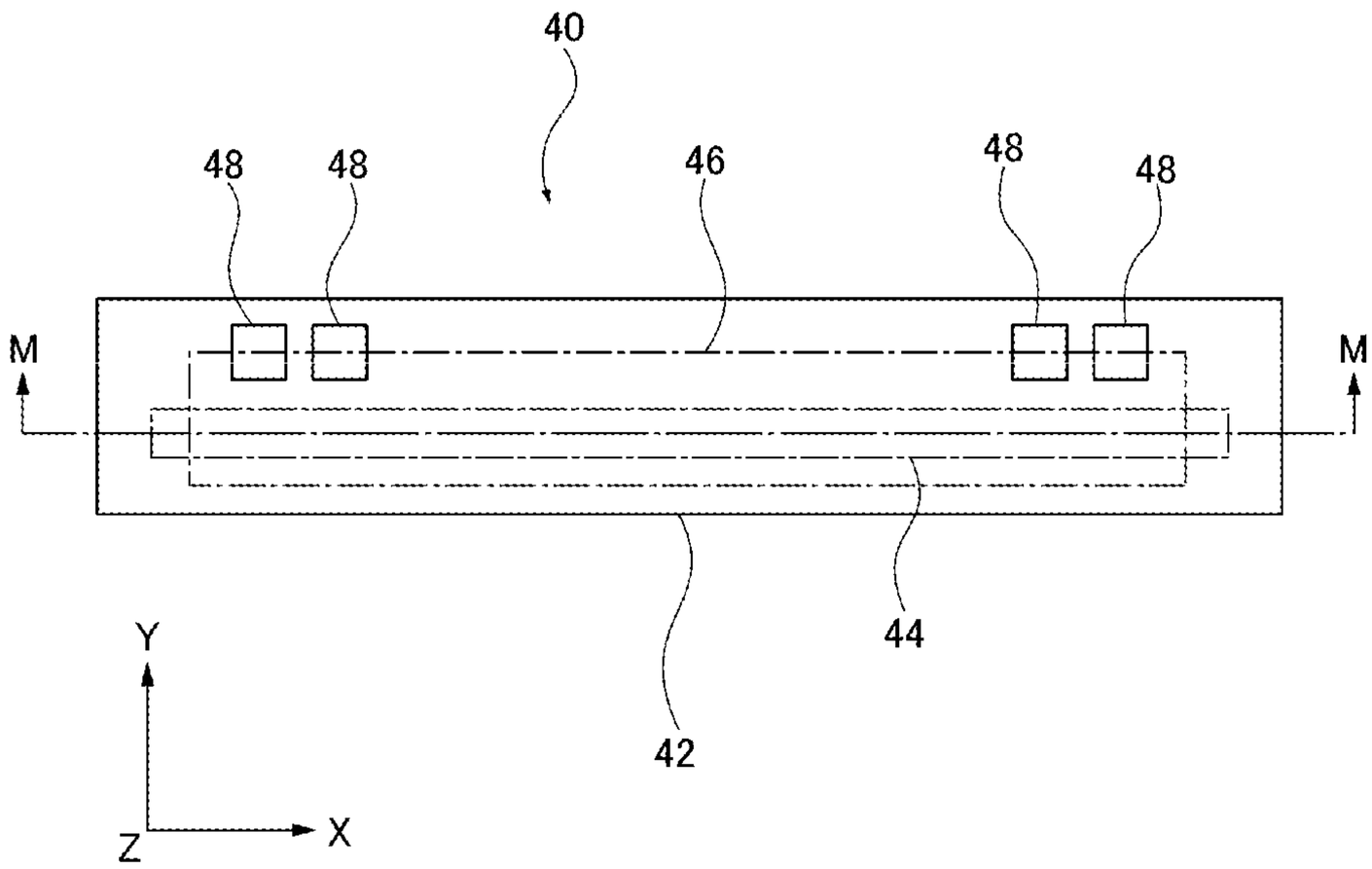


FIG 5

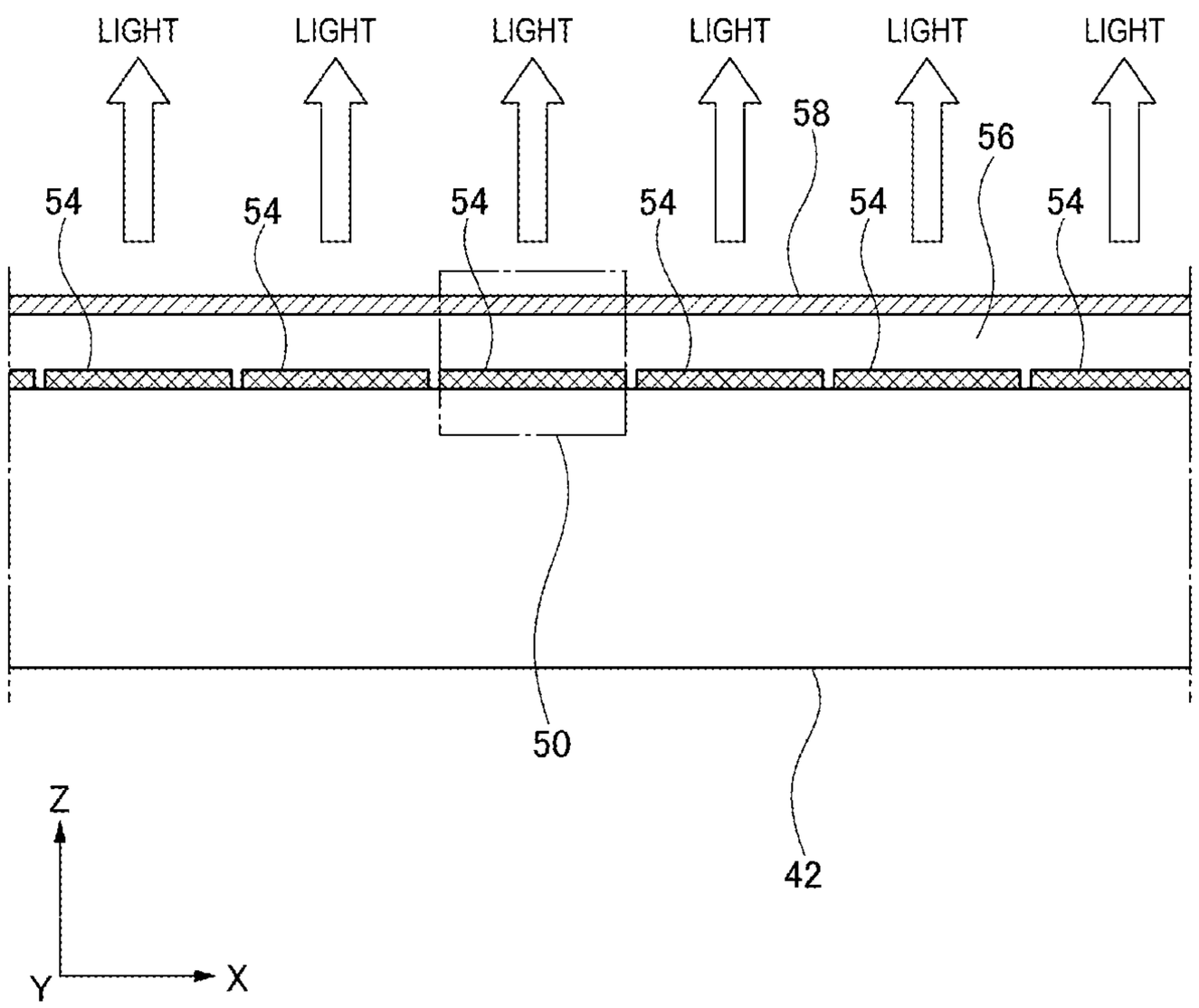

LIGHT
LIGHT
LIGHT
LIGHT
LIGHT
LIGHT
54
54
54
54
54
54
58
56
50
42
Z
Y
X

FIG 6

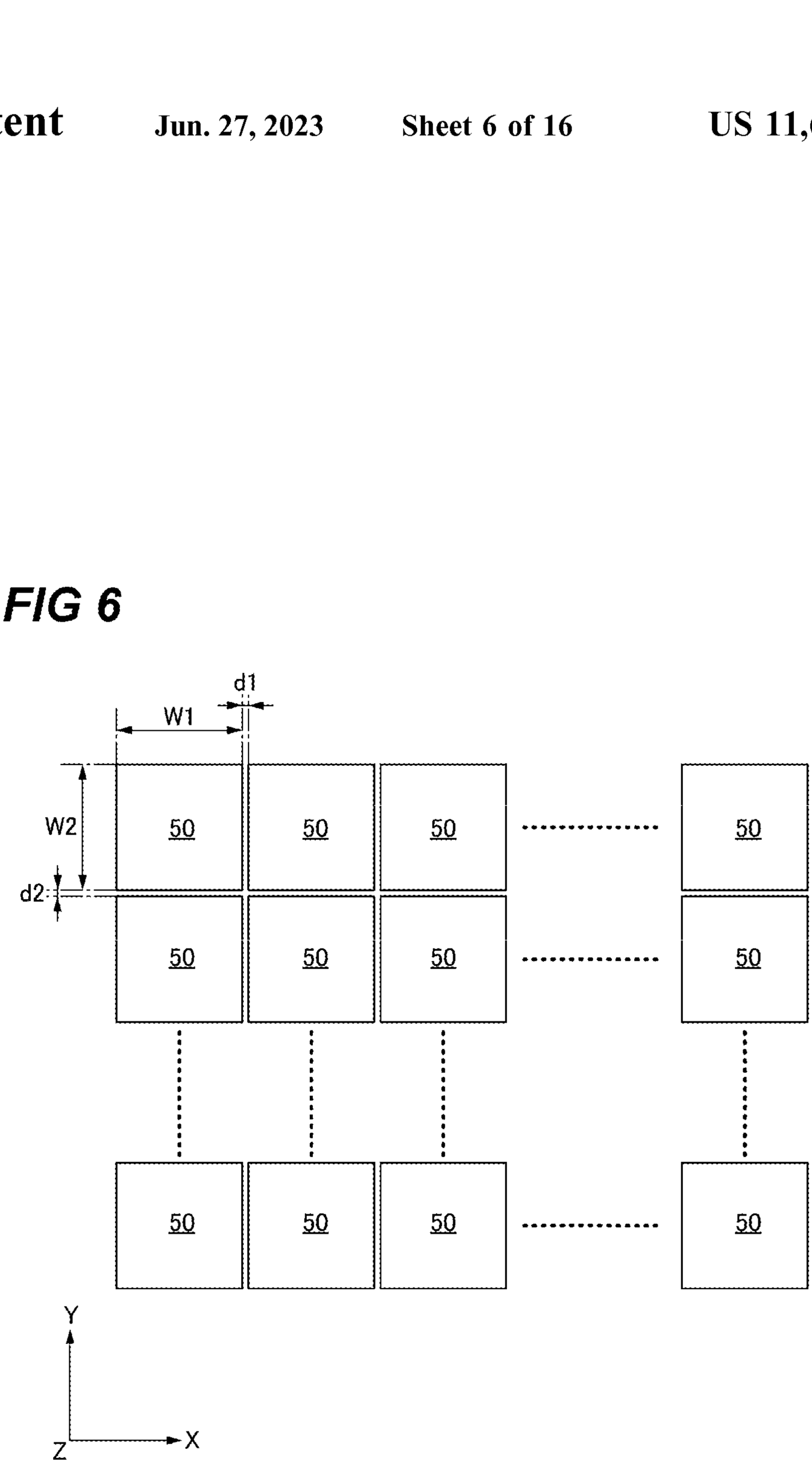


FIG 7A

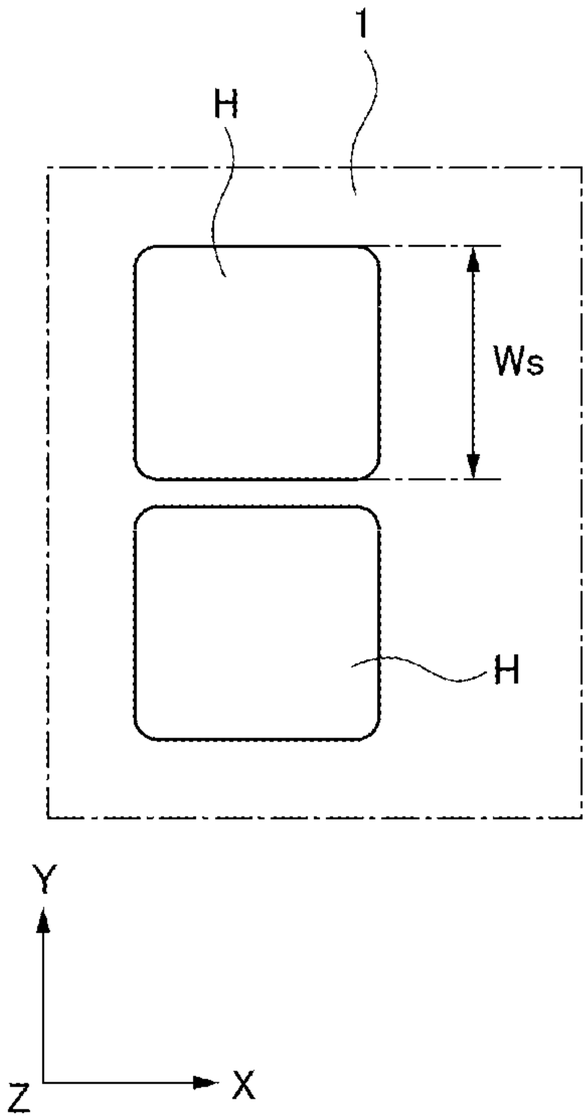
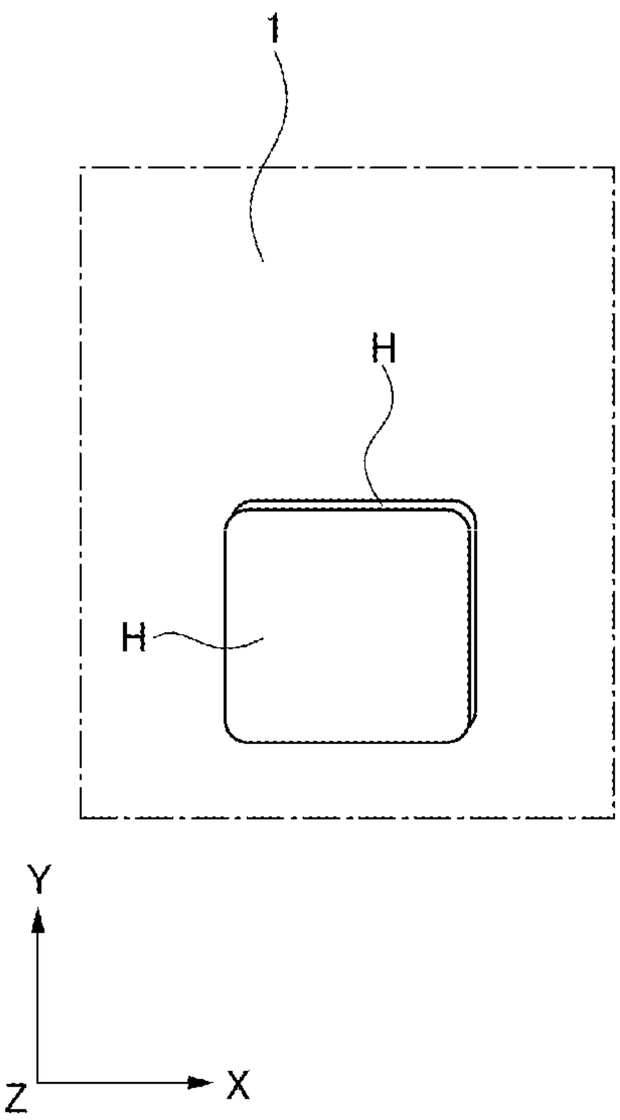


FIG 7B



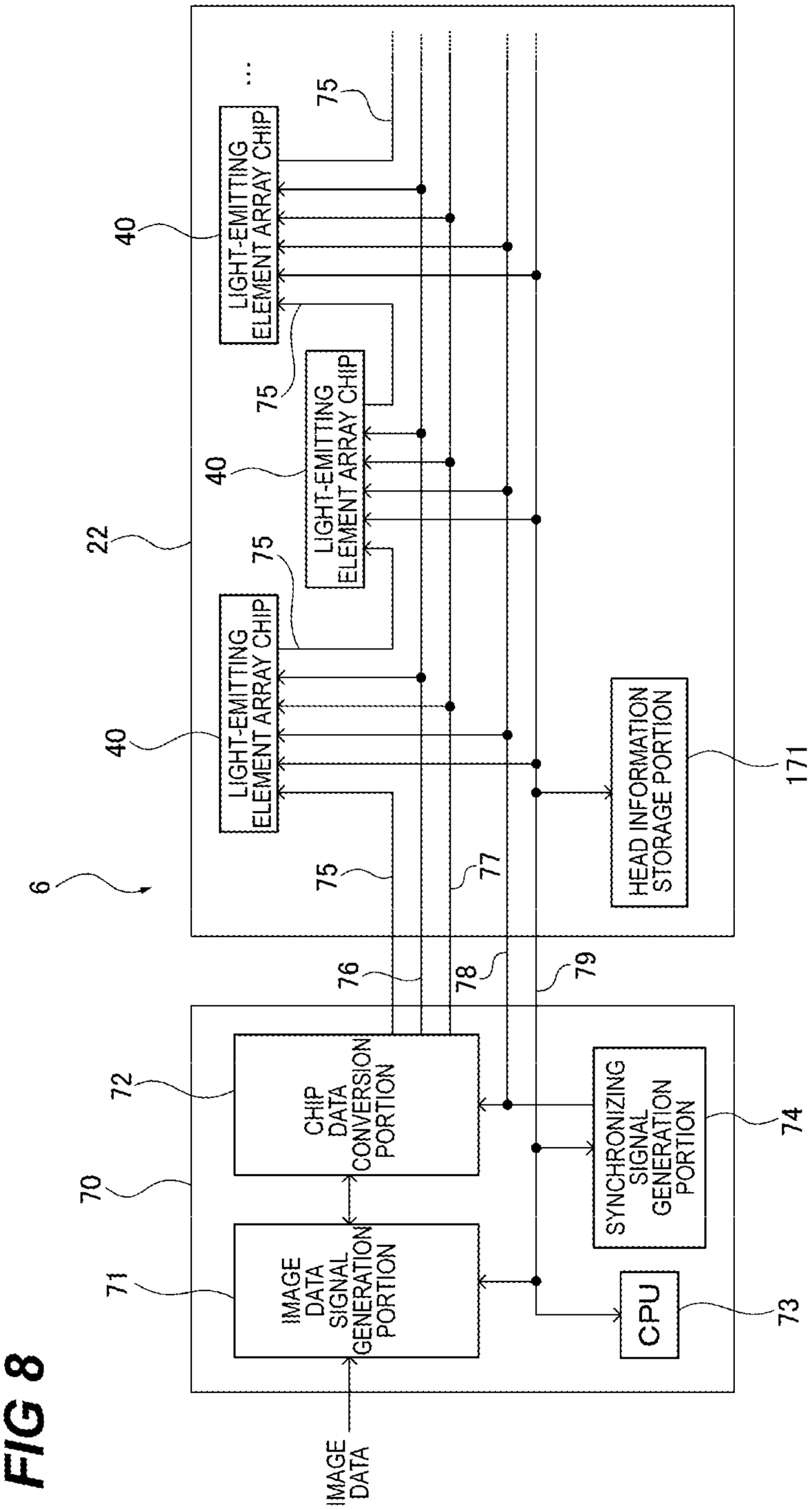

6
22
40
LIGHT-EMITTING ELEMENT ARRAY CHIP
75
77
76
78
79
171
HEAD INFORMATION STORAGE PORTION
70
71
72
IMAGE DATA SIGNAL GENERATION PORTION
CHIP DATA CONVERSION PORTION
CPU
73
74
SYNCHRONIZING SIGNAL GENERATION PORTION
IMAGE DATA

FIG 8

FIG 9

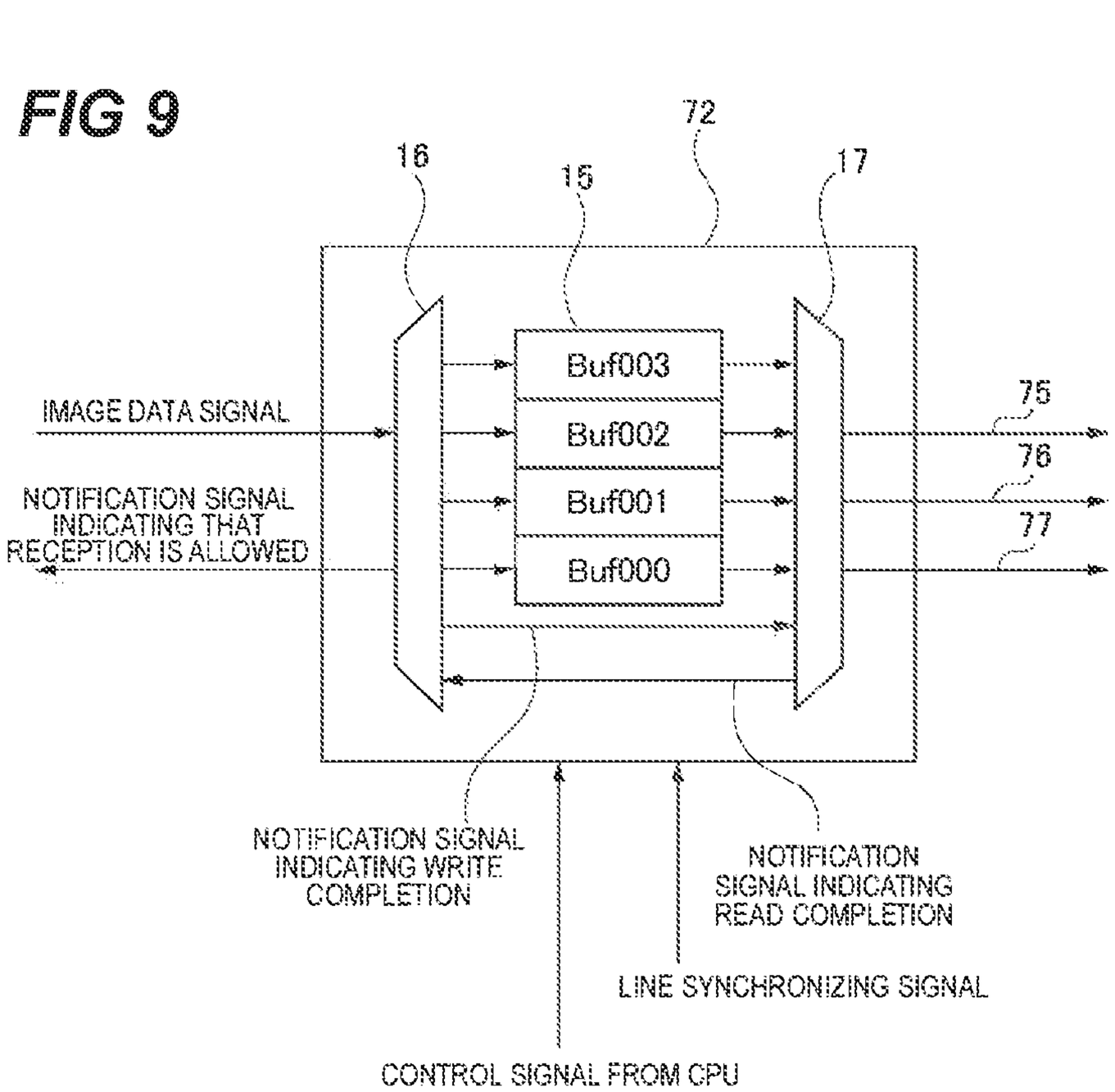
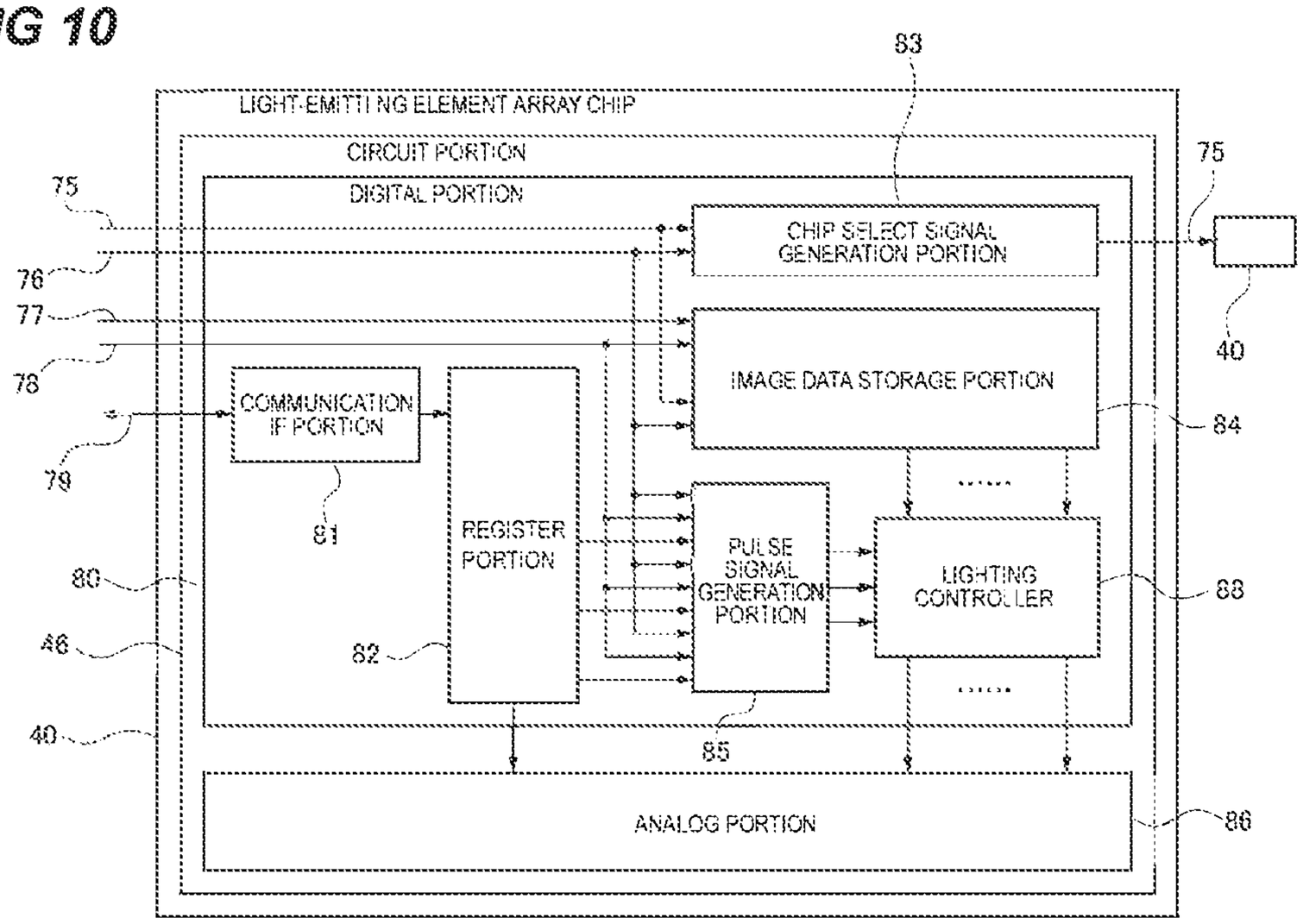
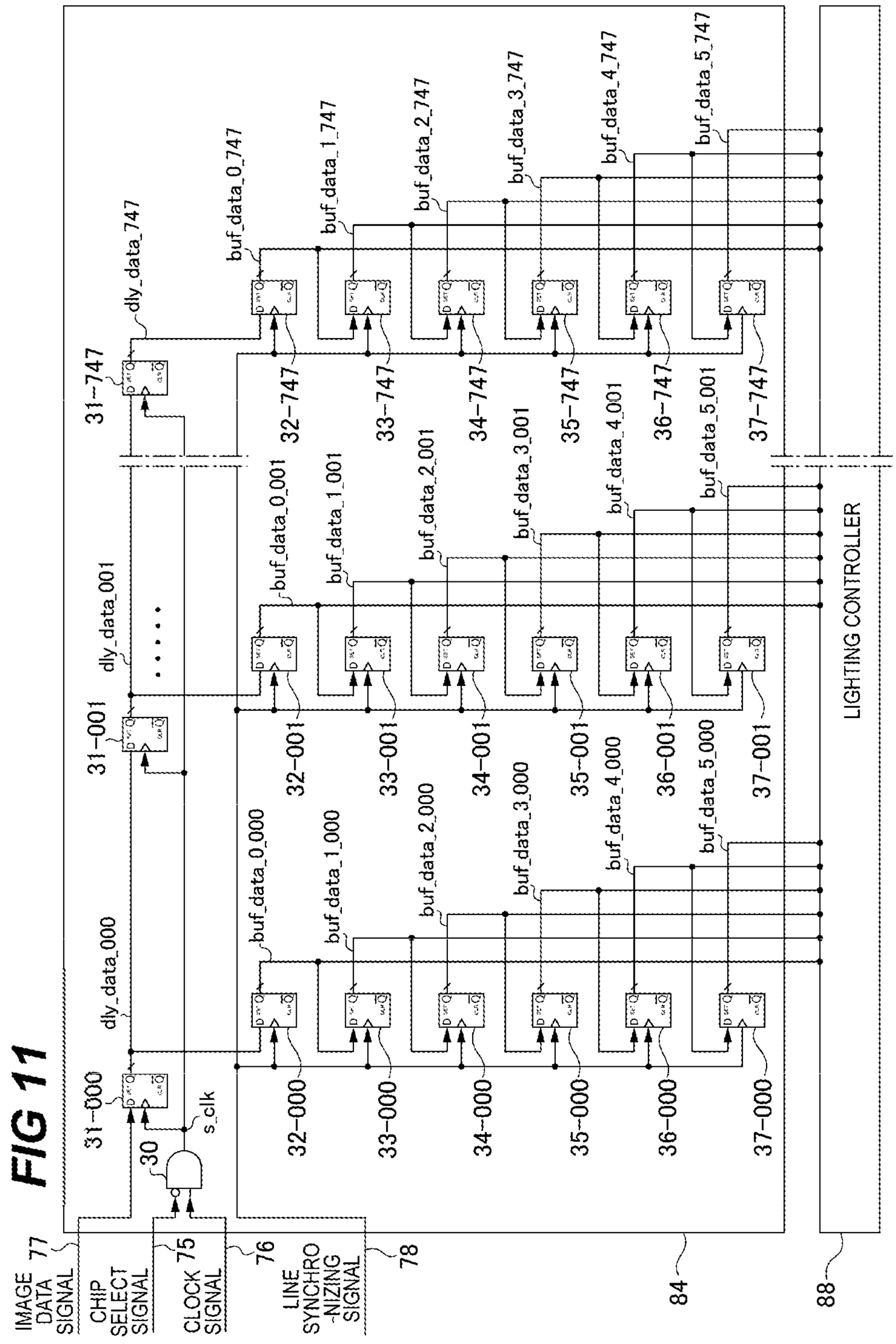

72
16
15
17
Buf003
Buf002
Buf001
Buf000
IMAGE DATA SIGNAL
NOTIFICATION SIGNAL INDICATING THAT RECEPTION IS ALLOWED
75
76
77
NOTIFICATION SIGNAL INDICATING WRITE COMPLETION
NOTIFICATION SIGNAL INDICATING READ COMPLETION
LINE SYNCHRONIZING SIGNAL
CONTROL SIGNAL FROM CPU

FIG 10


83
LIGHT-EMITTI NG ELEMENT ARRAY CHIP
CIRCUIT PORTION
DIGITAL PORTION
75
76
77
78
79
80
46
40
CHIP SELECT SIGNAL GENERATION PORTION
IMAGE DATA STORAGE PORTION
84
COMMUNICATION IF PORTION
81
REGISTER PORTION
82
PULSE SIGNAL GENERATION PORTION
85
LIGHTING CONTROLLER
88
ANALOG PORTION
86
75
40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buf_data_0_747
buf_data_1_747
buf_data_2_747
buf_data_3_747
buf_data_4_747
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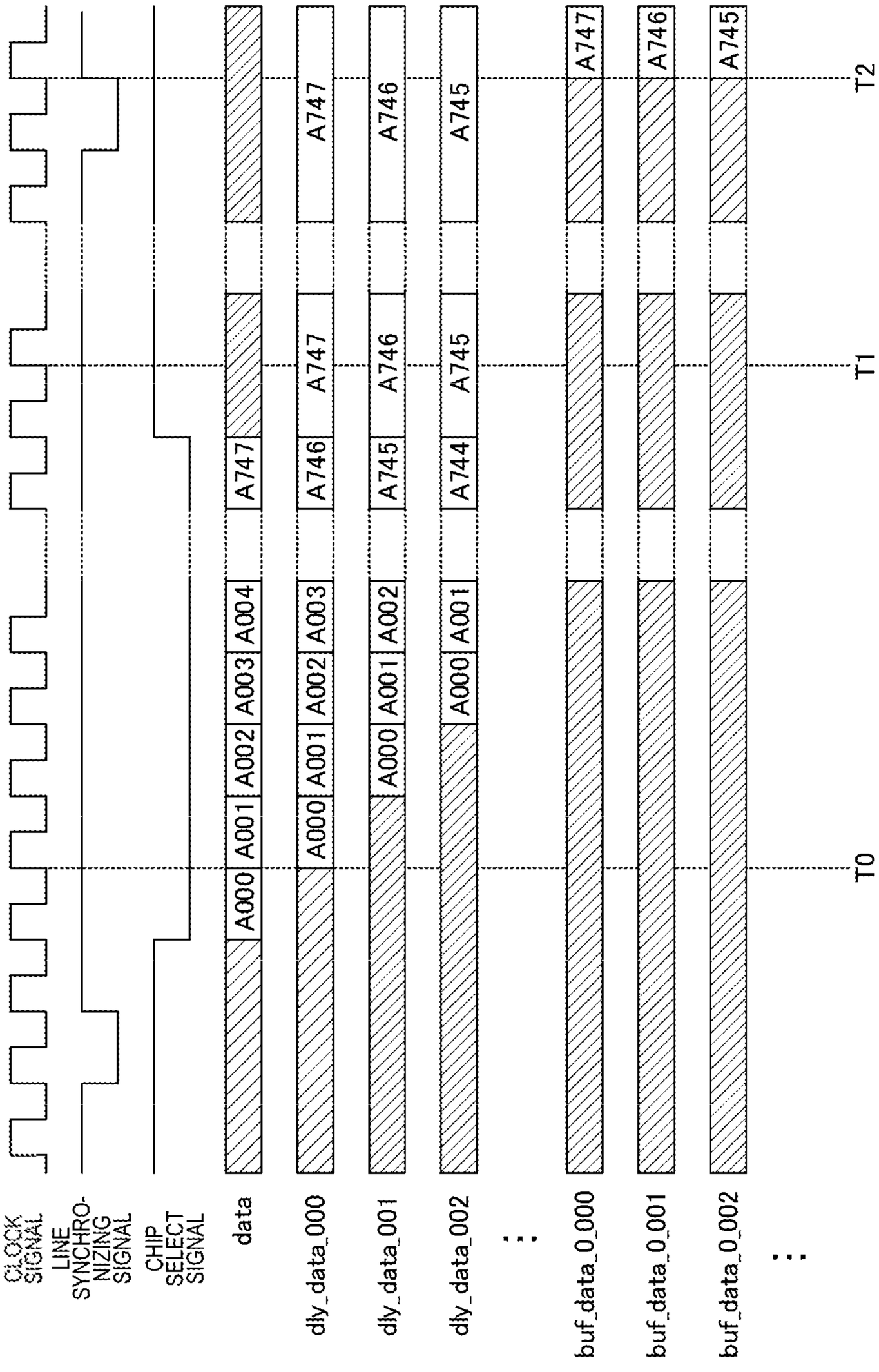
31-747
32-747
33-747
34-747
35-747
36-747
37-747
dly_data_001
buf_data_0_001
buf_data_1_001
buf_data_2_001
buf_data_3_001
buf_data_4_001
buf_data_5_001
31-001
32-001
33-001
34-001
35-001
36-001
37-001
dly_data_000
buf_data_0_000
buf_data_1_000
buf_data_2_000
buf_data_3_000
buf_data_4_000
buf_data_5_000
31-000
32-000
33-000
34-000
35-000
36-000
37-000
30
s_clk
LIGHTING CONTROLLER
IMAGE DATA SIGNAL 77
CHIP SELECT SIGNAL 75
CLOCK SIGNAL 76
LINE SYNCHRO-NIZING SIGNAL 78
84
88

FIG 11

FIG 12


CLOCK SIGNAL
LINE SYNCHRO-NIZING SIGNAL
CHIP SELECT SIGNAL
data
dly_data_000
dly_data_001
dly_data_002
buf_data_0_000
buf_data_0_001
buf_data_0_002
A747
A746
A745
A744
A000
A001
A002
A003
A004
T0
T1
T2

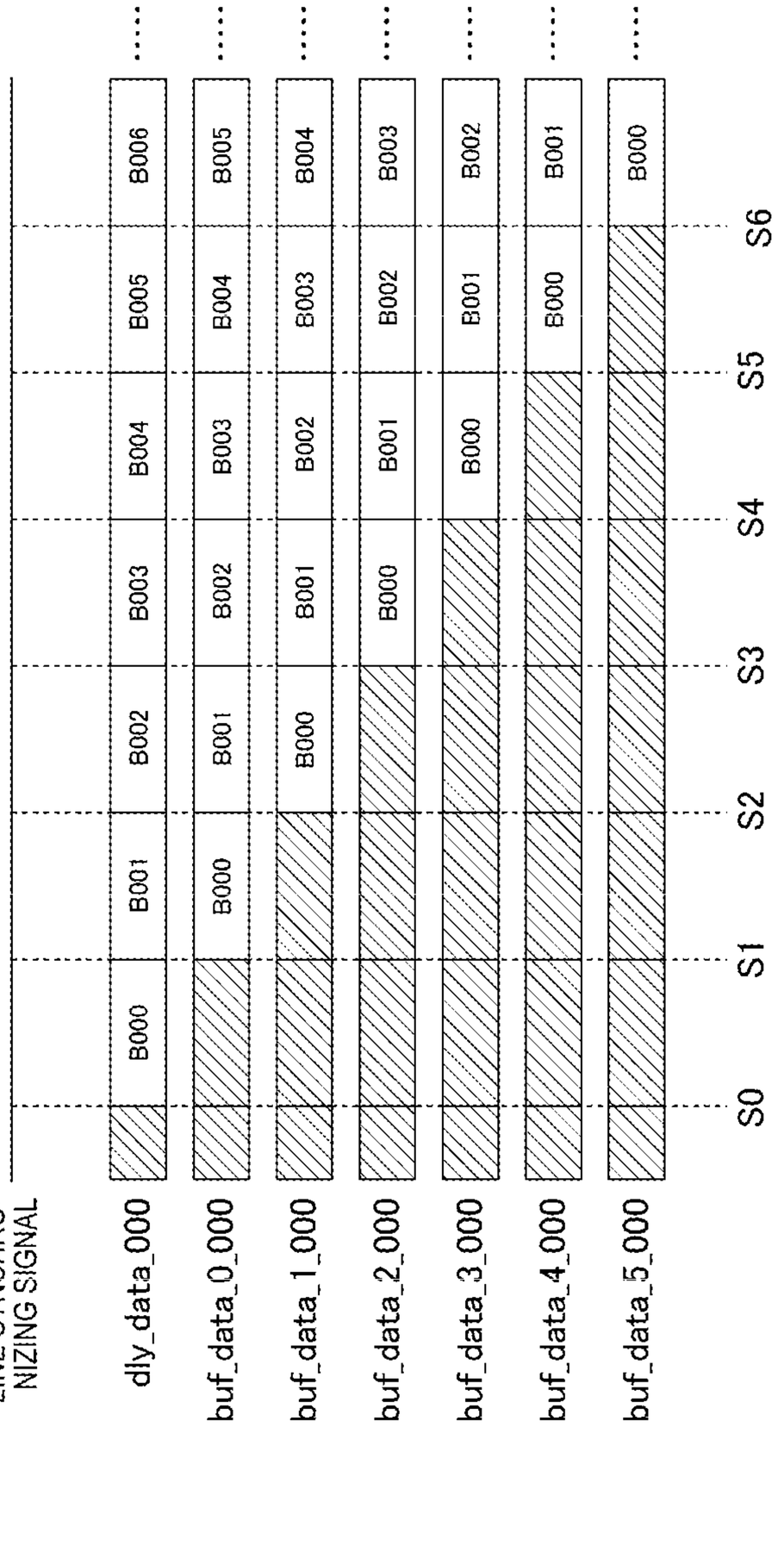

LINE SYNCHRO-NIZING SIGNAL
dly_data_000
buf_data_0_000
buf_data_1_000
buf_data_2_000
buf_data_3_000
buf_data_4_000
buf_data_5_000
B000
B001
B002
B003
B004
B005
B006
S0
S1
S2
S3
S4
S5
S6

FIG 13

FIG 14

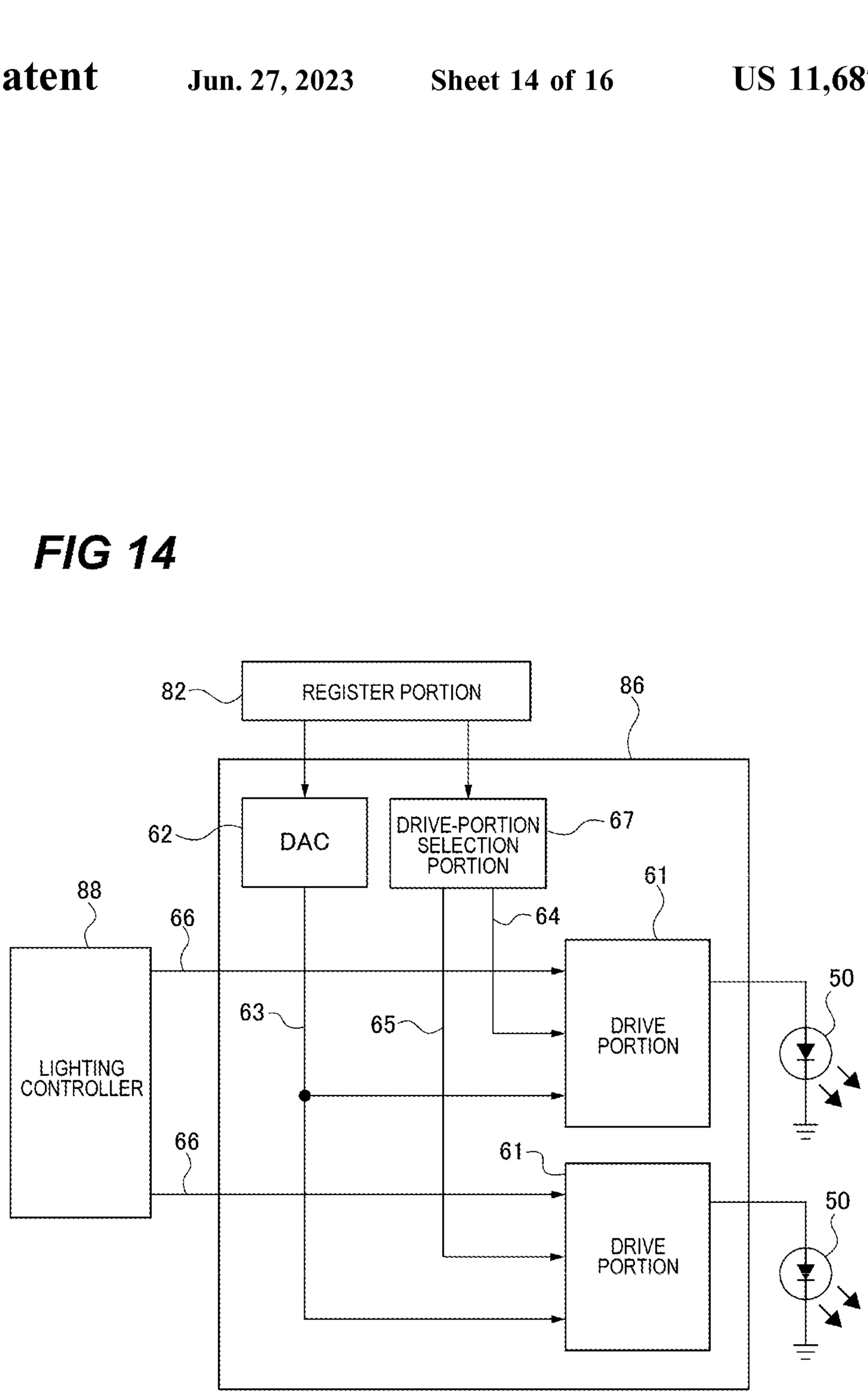

82
REGISTER PORTION
86
62
DAC
DRIVE-PORTION SELECTION PORTION
67
88
66
64
61
LIGHTING CONTROLLER
63
65
DRIVE PORTION
50
66
61
50
DRIVE PORTION

FIG 15

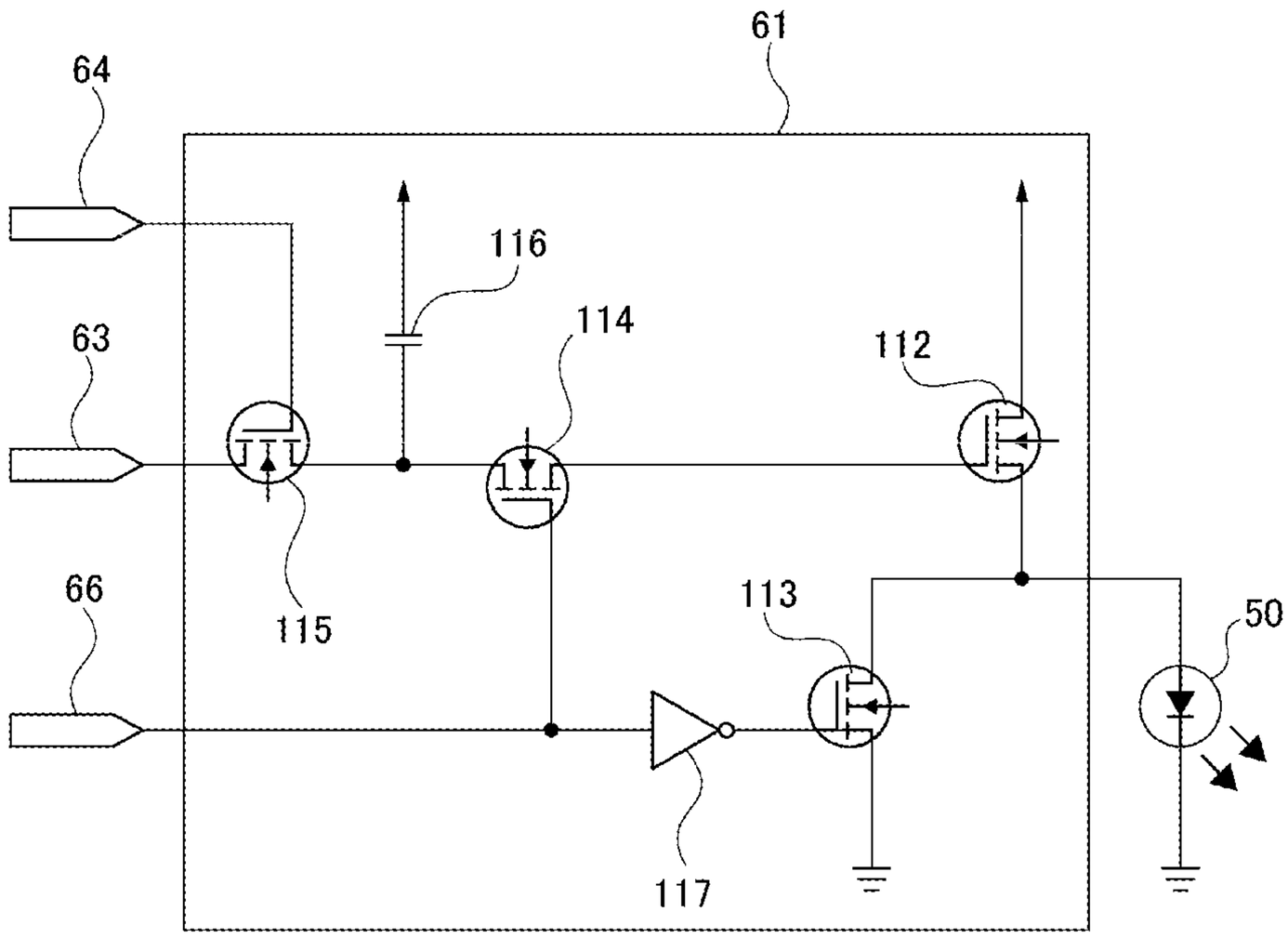


FIG 16

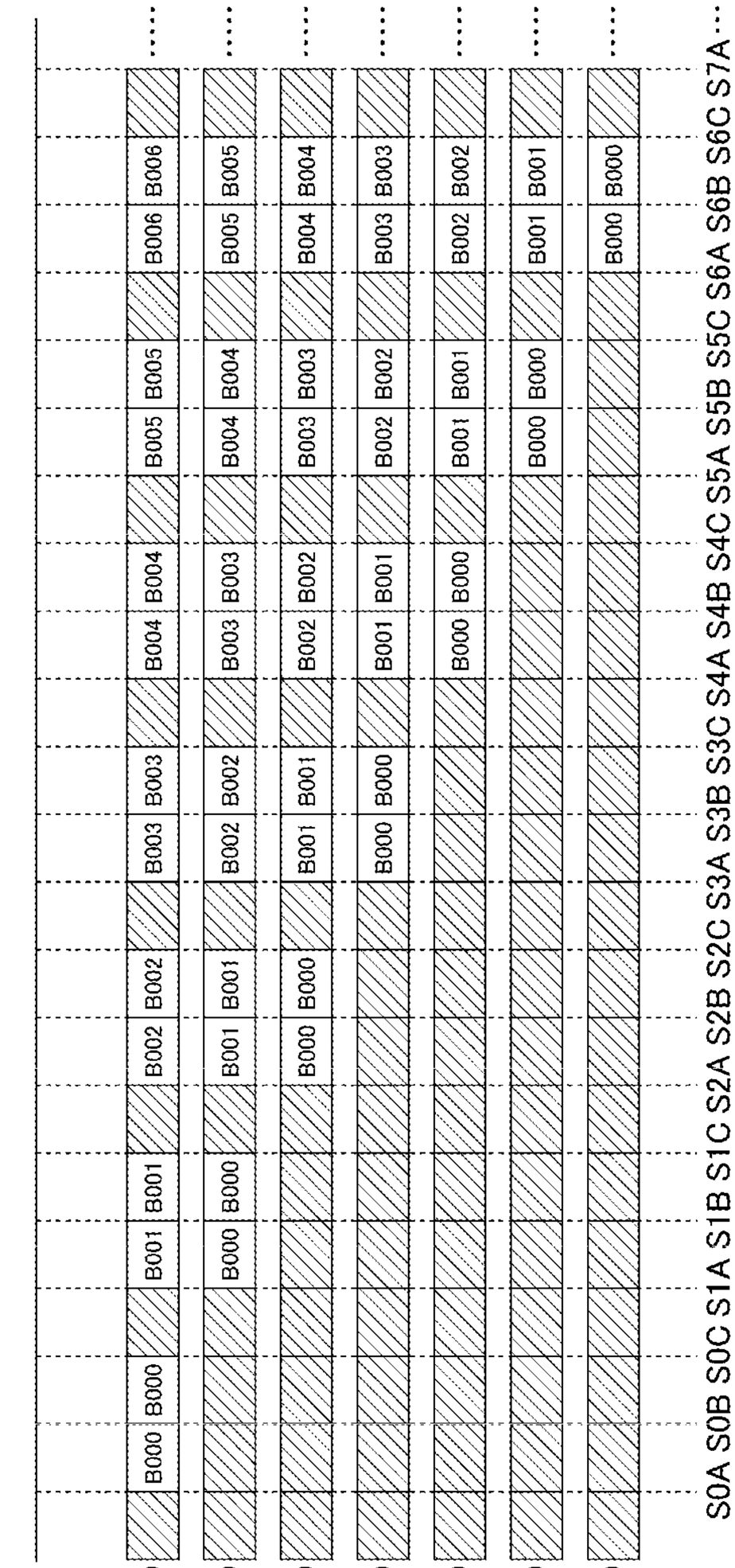

LINE SYNCHRO-NIZING SIGNAL
dly_data_000
buf_data_0_000
buf_data_1_000
buf_data_2_000
buf_data_3_000
buf_data_4_000
buf_data_5_000
S0A S0B S0C S1A S1B S1C S2A S2B S2C S3A S3B S3C S4A S4B S4C S5A S5B S5C S6A S6B S6C S7A

IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image forming apparatus including an exposure head.

Description of the Related Art

In image forming with an electrophotographic image forming apparatus, the surface of a photoconductive drum is irradiated with light corresponding to image data, so that an electrostatic latent image is formed on the surface of the photoconductive drum. After that, a developing portion causes toner to adhere to the electrostatic latent image on the surface of the photoconductive drum, to form a toner image. After the toner image is transferred to a sheet, a fixing portion fixes, by heating, the transferred toner image on the sheet to the sheet, so that an image is formed.

A sheet of thick paper is larger in heat capacity than a sheet relatively small in basis weight, such as a sheet of plain paper. Thus, when such a sheet of thick paper is used as a sheet for image forming, a large quantity of heat is required in order to fix a toner image to the sheet. Thus, it has been known that the conveyance rate of a sheet is set to a rate lower than the normal rate to lengthen the period during which a fixing portion heats a toner image supported on a sheet such that a larger quantity of heat is applied to the toner image and the sheet, enabling stable fixing of a toner image to a sheet of thick paper. That is, an image forming apparatus having such an arrangement as above has a normal mode in which a sheet is conveyed at the normal rate and a low mode in which a sheet is conveyed at a rate lower than the rate in the normal mode. Because the rotational rate of a photoconductive drum is related to the conveyance rate of a sheet, the rotational rate of the photoconductive drum is lower in the low mode than in the normal mode.

Japanese Patent Application Laid-Open No. 2015-112856 discloses an image forming apparatus including, as a device that irradiates a photoconductive drum with light to form an electrostatic latent image, an exposure head including a light-emitting portion having an LED or organic EL and a lens that causes light emitted from the light-emitting portion to form an image on the surface of the photoconductive drum. Use of such an exposure head enables reductions in the size and manufacturing cost of an image forming apparatus because the exposure head is less in the number of components than a laser-scanning device that causes laser light to deflection-scan through a rotatable polygonal mirror to form an electrostatic latent image.

An image forming apparatus equipped with an exposure head has a larger quantity of light to be emitted to the region corresponding to one pixel on a photoconductive drum in image forming in such a low mode as described above than in image forming in the normal mode. This is because the rotational rate of the photoconductive drum is lower in the low mode than in the normal mode, namely, the period during which light is emitted to the region corresponding to one pixel on the photoconductive drum is longer in the low mode than in the normal mode. In this case, excessive toner in developing an electrostatic latent image with a developing portion leads to an increase in toner consumption.

SUMMARY OF THE INVENTION

It is desirable to provide an image forming apparatus including an exposure head, enabling, even in image forming in a mode in which the rotational rate of a photoconductive drum is low, inhibition of excessive toner from adhering on the photoconductive drum.

According to a representative configuration of the present invention for achievement of the above, provided is an image forming apparatus including: a photoconductive drum; an exposure head including a plurality of light-emitting portions arranged along in a rotational-axis direction of the photoconductive drum, the plurality of light-emitting portions each being configured to emit light, based on an image data signal, for exposure of the photoconductive drum; a control signal generation portion configured to generate, at a predetermined cycle, a control signal that controls a timing of light emission of each of the plurality of light-emitting portions; an image data signal transmission portion configured to transmit the image data signal to the exposure head, in synchronization with the control signal, for light emission of each of the plurality of light-emitting portions based on the image data signal; and a controller configured to control the control signal generation portion, the image data signal transmission portion, and a rotational rate of the photoconductive drum, wherein the controller is allowed to perform a first mode in which the photoconductive drum rotates at a first rotational rate and a second mode in which the photoconductive drum rotates at a second rotational rate m/n times the first rotational rate, lower than the first rotational rate, and in the second mode, for exposure for forming an image for one line onto a sheet, causes the control signal generation portion to generate the control signal at a cycle 1/m times a cycle of the control signal generated in the first mode, and causes the image data signal transmission portion to transmit, to the exposure head, the same image data signal m times and transmit, to the exposure head, the image data signal that brings the plurality of light-emitting portions into no light emission n-m times, in synchronization with n number of the control signals.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of an image forming apparatus;

FIGS. **2**A and **2**B are, respectively, a perspective view and a sectional view of a photoconductive drum and an exposure head;

FIGS. **3**A, **3**B, and **3**C each illustrate either mounted face of a printed circuit board included in the exposure head;

FIG. **4** is a schematic view of a light-emitting element array chip;

FIG. **5** is a sectional view of the light-emitting element array chip;

FIG. **6** is an explanatory schematic view of the arrangement of light-emitting portions;

FIGS. **7**A and **7**B are explanatory schematic views of the irradiated positions of a photoconductive drum with light emitted from two light-emitting portions adjacent in the sub-scanning direction;

FIG. **8** is a block diagram of the system configuration of an image controller and an exposure head;

FIG. **9** is a block diagram of the configuration of a chip data conversion portion;

FIG. **10** is a block diagram of the system configuration of a light-emitting element array chip;

FIG. **11** is a circuit configuration diagram of an image data storage portion;

FIG. **12** is a timing chart of the operation in the main scanning direction of the image data storage portion;

FIG. **13** is a timing chart of the operation in the sub-scanning direction of the image data storage portion in the normal mode;

FIG. **14** is a block diagram of the configuration of an analog portion;

FIG. **15** is a circuit diagram of a drive portion; and

FIG. **16** is a timing chart of the operation in the sub-scanning direction of the image data storage portion in the low mode.

DESCRIPTION OF THE EMBODIMENTS

<Image Forming Apparatus>

The entire configuration of an image forming apparatus A according to an embodiment of the present invention will be described below together with the operation at the time of image forming with reference to the drawings. Note that, unless otherwise specified, the dimensions, material, and shape of each of the following constituent components and the relative arrangement thereof should not be construed to limit the scope of the invention.

The image forming apparatus A serves as a full-color image forming apparatus that transfers, to a sheet, respective images of four-color toners of yellow Y, magenta M, cyan C, and black K, to form an image. Note that, in the following description, members that involve the yellow toner are denoted with Y as the suffix, members that involve the magenta toner are denoted with M as the suffix, members that involve the cyan toner are denoted with C as the suffix, and members that involve the black toner are denoted with K as the suffix. However, the configurations and operations of the members are substantially the same except for the colors of toner. Thus, the suffixes thereof will be appropriately omitted when no distinction is required.

FIG. **1** is a schematic sectional view of the image forming apparatus A. As illustrated in FIG. **1**, the image forming apparatus A includes an image forming portion that forms an image. The image forming portion includes photoconductive drums **1** (**1**Y, **1**M, **1**C, and **1**K), charging devices **2** (**2**Y, **2**M, **2**C, and **2**K), and exposure heads **6** (**6**Y, **6**M, **6**C, and **6**K). The image forming portion includes developing devices **4** (**4**Y, **4**M, **4**C, and **4**K) as a developing portion, transfer devices **5** (**5**Y, **5**M, **5**C, and **5**K) as a transfer portion, and a conveying belt **11**.

The image forming apparatus A includes a touch-panel operation portion **300** (detection portion) that a user operates for various types of setting regarding image forming. For example, the user operates the operation portion **300** to designate the number of sheets for image forming or the size of a sheet for image forming. The user operates the operation portion **300** to input the basis weight of a sheet S housed in a sheet cassette **99***a* or **99***b* (e.g., thick paper, plain paper, or the brand of a sheet). Note that, for example, instead of being input through the operation portion **300**, the basis weight of a sheet S may be measured by a sensor **38** (detection portion) disposed in a conveyance path.

As the sensor **38** that measures a basis weight, for example, a transmissive optical sensor can be used. Such a transmissive optical sensor is achieved by a combination of a light-emitting element, such as an LED, and a light-receiving element, such as a photodiode. When a sheet S blocks light emitted from the light-emitting element toward the light-receiving element, a reduction is made in the light quantity that the light-receiving element receives. The light-receiving element converts the received light quantity into a voltage value and functions as a switch with a predetermined threshold set in voltage level.

In general, as the basis weight of a sheet S for image forming increases, its thickness increases. In a case where a sheet S is made of thin paper small in basis weight, light emitted from an LED passes through the sheet S. In a case where a sheet S is made of thick paper large in basis weight, light emitted from the LED hardly passes through the sheet S. Thus, focusing on the relationship between the sensor **38** and the basis weight of a sheet S, the received light quantity of the light-receiving element at the front end or rear end portion of a sheet S that passes through the sensor **38** is measured with the light-emitting element remaining constant in the quantity of light emission, so that the basis weight of a sheet S can be predicted. Because an image tends to be less formed at the front end or rear end of a sheet S than at a portion near the center thereof, use of such an end portion as the position of measurement aims at a rise in the accuracy of measurement.

The operation portion **300** and the sensor **38** are electrically in connection with a CPU **73** illustrated in FIG. **8**. According to the basis weight of a sheet S detected from the operation portion **300** or the sensor **38**, the CPU **73** controls the rotational rate of each type of roller that conveys a sheet S, to set the conveyance rate of a sheet S at the time of image forming. The conveyance rate of a sheet S herein is defined as the rate at which a sheet S passes through a fixing device **94** (fixing portion).

For example, the CPU **73** sets, for image forming, the conveyance rate of a sheet S lower in the low mode in which an image is formed on a sheet S made of thick paper having a basis weight not less than a predetermined basis weight than in the normal mode in which an image is formed on a sheet S made of plain paper having a basis weight less than the predetermined basis weight. Because the rotational rate of each photoconductive drum **1** is related to the conveyance rate of a sheet S, the CPU **73** sets the rotational rate of each photoconductive drum **1** lower in the low mode (second mode) than in the normal mode (first mode).

Thus, the period during which the fixing device **94** heats a toner image supported on a sheet S large in basis weight is lengthened such that a larger quantity of heat is applied to the toner image and the sheet S, enabling stable fixing of the toner image to the sheet S large in heat capacity. Note that the timing at which the CPU **73** makes a switch between the low mode and the normal mode is not limited to the above timing. For example, the CPU **73** may set the low mode at the time of image forming higher in quality than normal image forming such that the resolution in the sub-scanning direction identical to the rotation direction of each photoconductive drum **1** is higher in the low mode than in the normal mode.

Next, the image forming operation of the image forming apparatus A will be described. For image forming, a sheet S housed in the sheet cassette **99***a* is sent to a registration roller **96** by a pickup roller **91***a*, a feed roller **92***a*, and conveying rollers **93***b* and **93***c* or a sheet S housed in the sheet cassette **99***b* is sent to the registration roller **96** by a pickup roller **91***b*, a feed roller **92***b*, and a conveying roller **93***a* in addition to the conveying rollers **93***b* and **93***c*. After that, the sheet S is fed to the conveying belt **11** at a predetermined timing by the registration roller **96**.

Meanwhile, in the image forming portion, the charging device **2**Y charges the surface of the photoconductive drum **1**Y Next, according to image data read by an image reading portion **90** or image data transmitted from an external device (not illustrated), the exposure head **6**Y irradiates the surface

of the photoconductive drum **10**Y with light to form an electrostatic latent image on the surface of the photoconductive drum **10**Y After that, the developing device **4**Y causes yellow toner to adhere to the electrostatic latent image formed on the surface of the photoconductive drum **1**Y to form a yellow toner image on the surface of the photoconductive drum **1**Y Due to application of a transfer bias to the transfer device **5**Y, the toner image formed on the surface of the photoconductive drum **1**Y is transferred to the sheet S being conveyed by the conveying belt **11**.

Due to similar processes, the exposure heads **6**M, **6**C, and **6**K irradiate, respectively, the photoconductive drums **1**M, **1**C, and **1**K with light, to form electrostatic latent images, and then the developing devices **4**M, **4**C, and **4**K form magenta, cyan, and black toner images, respectively. Then, due to application of a transfer bias to each of the transfer devices **5**M, **5**C, and **5**K, each toner image is transferred so as to be superimposed on the yellow toner image on the sheet S. Thus, a full-color toner image corresponding to the image data is formed on the surface of the sheet S.

After that, the sheet S supporting the toner image is conveyed to the fixing device **94** by a conveying belt **97**, and then is subjected to heating and pressing by the fixing device **94**. Thus, the toner image on the sheet S is fixed to the sheet S. After that, the sheet S having the toner image fixed thereto is discharged to a discharge tray **95** by a discharge roller **98**.

<Exposure Head>

Next, the configuration of an exposure head **6** will be described.

FIG. **2**A is a perspective view of a photoconductive drum **1** and an exposure head **6**. FIG. **2**B is a sectional view of the photoconductive drum **1** and the exposure head **6**. FIGS. **3**A and **3**B illustrate, respectively, one mounted face and the other mounted face of a printed circuit board **22** included in the exposure head **6**. FIG. **3**C is an enlarged view of a region V illustrated in FIG. **3**B.

Referring to FIGS. **2**A and **2**B, the exposure head **6** is fixed, opposite the surface of the photoconductive drum **1**, by a fixing member (not illustrated). The exposure head **6** includes a light-emitting element array chip **40** that emits light, in addition to the printed circuit board **22** on which the light-emitting element array chip **40** is mounted. The exposure head **6** includes a rod lens array **23** that causes light emitted from the light-emitting element array chip **40** to form an image (to focus) on the photoconductive drum **1**, and a housing **24** to which the rod lens array **23** and the printed circuit board **22** are fixed.

A connector **21** is mounted on the face opposite to the mounted face on which the printed circuit board **22** has the light-emitting element array chip **40**. The connector **21** is provided for transmission of a control signal from an image controller **70** (refer to FIG. **8**) to the light-emitting element array chip **40** and for connection of a power-supply line. The light-emitting element array chip **40** is driven through the connector **21**.

Referring to FIGS. **3**A, **3**B, and **3**C, 20 light-emitting element array chips **40** are mounted in two rows and in a staggered pattern on the printed circuit board **22**. Each light-emitting element array chip **40** includes 748 light-emitting portions **50** arranged at predetermined resolution pitches in its longitudinal direction (X direction). Each light-emitting element array chip **40** includes light-emitting portions **50** arranged at predetermined pitches in its lateral direction (Y direction). That is, each light-emitting element array chip **40** includes light-emitting portions **50** arranged two-dimensionally in the X direction and in the Y direction orthogonal to the X direction.

In the present embodiment, the resolution pitch of each light-emitting element array chip **40** is 1200 dpi (approximately 21.16 m). The distance from one end to the other end in the longitudinal direction of the light-emitting portions **50** included in each light-emitting element array chip **40** is approximately 15.8 mm. That is, the exposure head **6** includes 14960 light-emitting portions **50** in total in the X direction, enabling exposure processing corresponding to an image width of approximately 316 mm (≈approximately 15.8 mm×20 chips) in the longitudinal direction.

The interval L**1** between the centers of the light-emitting portions **50** mutually closest in the longitudinal direction between adjacent light-emitting element array chips **40** is approximately 21.16 m. That is, the pitch between each light-emitting portion **50** in the longitudinal direction at the boundary portion between each light-emitting element array chip **40** corresponds to a resolution of 1200 dpi. The interval L**2** between the centers of the light-emitting portions **50** mutually closest in the lateral direction (Y direction) between light-emitting element array chips **40** arranged in two rows is approximately 105 μm (corresponds to five pixels in 1200 dpi).

In the present embodiment, the X direction identical to the longitudinal direction of each light-emitting element array chip **40** corresponds to the rotational-axis direction of the photoconductive drum **1**, and the Y direction identical to the lateral direction of each light-emitting element array chip **40** corresponds to the rotational direction of the photoconductive drum **1**. The Z direction corresponds to the stack direction of the layers in each light-emitting portion **50** having a layered structure to be described below and also corresponds to the direction in which each light-emitting portion **50** emits light. Note that the longitudinal direction of each light-emitting element array chip **40** may have an angle of approximately ±1° with respect to the rotational-axis direction of the photoconductive drum **1**. The lateral direction of each light-emitting element array chip **40** may have an angle of approximately ±1° with respect to the rotational direction of the photoconductive drum **1**.

<Light-Emitting Element Array Chip>

Next, the configuration of a light-emitting element array chip **40** will be described.

FIG. **4** is a schematic view of a light-emitting element array chip **40**. FIG. **5** is a sectional view taken along line M-M of FIG. **4**. FIG. **6** is an explanatory schematic view of the arrangement of light-emitting portions **50**.

As illustrated in FIG. **4**, the light-emitting element array chip **40** includes a light-emitting substrate **42** having a circuit portion **46** that controls each light-emitting portion **50**, built therein, a light-emitting region **44** in which the plurality of light-emitting portions **50** is disposed regularly on the light-emitting substrate **42**, and wire-bonding pads **48**. Signal output/signal input between the circuit portion **46** and the outside of the light-emitting element array chip **40** and power supply to the circuit portion **46** are performed through the wire-bonding pads **48**. Note that, as the circuit portion **46**, an analog drive circuit, a digital control circuit, or a circuit including both thereof can be used.

As illustrated in FIG. **5**, the light-emitting portions **50** are formed with the light-emitting substrate **42**, a plurality of lower electrodes **54** two-dimensionally arranged at regular intervals in the X direction (at intervals d**1** as illustrated in FIG. **6**) and at regular intervals in the Y direction (at intervals d**2** as illustrated in FIG. **6**) on the light-emitting substrate **42**, a light-emitting layer **56**, and an upper electrode **58**.

The plurality of lower electrodes **54** (first electrode layer including a plurality of electrodes) is layered and separated from each other on the light-emitting substrate **42**, and each is provided corresponding to a pixel. That is, each lower electrode **54** is provided for formation of one pixel.

The upper electrode **58** (second electrode layer) is stacked on the light-emitting layer **56** opposite the lower electrodes **54** through the light-emitting layer **56**. The upper electrode **58** allows light having the wavelength of light emission of the light-emitting layer **56**, to pass therethrough.

The circuit portion **46** controls the potential of a lower electrode **54** selected based on a control signal generated according to image data, to cause a potential difference between the selected lower electrode **54** and the upper electrode **58**. The potential difference between the upper electrode **58** serving as the anode and the lower electrode **54** serving as the cathode causes electrons to flow from the cathode into the light-emitting layer **56** and electron holes to flow from the anode into the light-emitting layer **56**. Recombination of the electrons and electron holes in the light-emitting layer **56** brings the light-emitting layer **56** into light emission.

Light to the upper electrode **58** due to light emission of the light-emitting layer **56** is emitted through the upper electrode **58**. Light from the light-emitting layer **56** to the lower electrode **54** is reflected from the lower electrode **54** to the upper electrode **58**, so that the reflected light is emitted through the upper electrode **58**. As above, the light-emitting portion **50** emits light. Note that a time lag occurs in emission timing between the light emitted directly from the light-emitting layer **56** through the upper electrode **58** and the light emitted through the upper electrode **58** after reflected from the lower electrode **54**, but the respective emission timings thereof can be regarded as substantially the same because the thickness of the light-emitting portion **50** is extremely thin.

Note that, in the present embodiment, the light-emitting substrate **42** is a silicon substrate. Preferably, the upper electrode **58** is transparent to the wavelength of light emission of the light-emitting layer **56**. For example, use of a transparent electrode of indium tin oxide (ITO) leads to substantially 100% in aperture ratio, so that light emitted in the light-emitting layer **56** is emitted through the upper electrode **58** without any change. In the present embodiment, the upper electrode **58** serves as the anode provided in common to the lower electrodes **54**. However, upper electrodes **58** may be provided one-to-one to the lower electrodes **54**, or one upper electrode **58** may be provided for every predetermined multiple of lower electrodes **54**.

As the light-emitting layer **56**, for example, an organic EL layer or an inorganic EL layer is used. In a case where an organic EL layer is used as the light-emitting layer **56**, the light-emitting layer **56** may be a stack structure including, as necessary, a functional layer, such as an electron transport layer, a hole transport layer, an electron injection layer, a hole injection layer, an electron blocking layer, or a hole blocking layer. The light-emitting layer **56** may be continuously formed in the X direction or may be divided into parts each similar in size to a lower electrode **54**. The lower electrodes **54** may be brought into a plurality of groups, and one light-emitting layer **56** may be stacked on the lower electrodes **54** belonging to each group.

Note that, in a case where an organic EL layer or an inorganic EL layer that is made of a light-emitting material vulnerable to moisture, is used as the light-emitting layer **56**, desirably, the light-emitting region **44** is sealed against moisture intrusion. For sealing, as a sealing film, for example, a thin film of silicon oxide, a thin film of silicon nitride, and a thin film of aluminum oxide are formed singly or in a stack. Preferably, a method of forming a sealing film excels in the performance of coating a step structure, and thus, for example, an atomic layer deposition (ALD) method can be used. Note that the material and configuration of a sealing film and the method of forming a sealing film are not limited to the above examples, and thus appropriate selections can be made.

As the material of the lower electrodes **54**, preferably, used is a metal high in reflectivity to the wavelength of light emission of the light-emitting layer **56**. For example, Ag, Al, or an alloy of Ag and Al is used. The lower electrodes **54** are formed in an Si process together with formation of the circuit portion **46** and are directly connected to the drive portion of the circuit portion **46**. As above, the formation of the lower electrodes **54** due to an Si process leads to a process rule of approximately 0.2 m that is high in accuracy, so that the lower electrodes **54** can be accurately disposed at a high density. Furthermore, because the lower electrodes **54** can be disposed at a high density, most of the light-emitting region **44** can be brought into light emission, so that a rise can be made in the utilization efficiency of the light-emitting region **44**. Note that the space between each lower electrode **54** is filled with the organic material of the light-emitting layer **56**, so that each lower electrode **54** is partitioned by the organic material.

Here, the current that flows in a light-emitting portion **50** and the quantity of light emission are substantially in a proportional relationship. Thus, control of the current that flows in the light-emitting portion **50** enables control of the light quantity of the light-emitting portion **50**. The light-emitting portion **50** has a threshold voltage. When the voltage across both ends of the light-emitting portion **50** exceeds the threshold voltage, current starts to flow in the light-emitting portion **50**. Then, as the voltage increases, the current increases almost linearly. Because variations are present in threshold voltage between light-emitting portions **50**, the voltage at which current starts to flow slightly varies between light-emitting portions **50**. Thus, before product shipping from a factory, the light-emitting portions **50** in a light-emitting element array chip **40** are individually brought into light emission in sequence, and the current that flows in each light-emitting portion **50** is adjusted such that light focused through the rod lens array **23** has a predetermined light quantity. Note that, before product shipping from a factory, an exposure head **6** is subjected not only to such adjustment in light quantity as described above but also to focus adjustment that is adjustment of the interval between each light-emitting element array chip **40** and the rod lens array **23**.

As illustrated in FIG. **6**, the light-emitting portions **50** are two-dimensionally arranged at predetermined intervals in the X direction and at predetermined intervals in the Y direction in the light-emitting region **44**. That is, in the light-emitting region **44** of one light-emitting element array chip **40**, a plurality of light-emitting portions **50** is arranged in the X direction, and a light-emitting row is formed of the plurality of light-emitting portions **50** arranged in the X direction. Such a plurality of light-emitting rows is arranged in the Y direction. In the present embodiment, the number of light-emitting rows is six.

In the present embodiment, the width W**1** in the X direction of each light-emitting portion **50** is 20.90 μm, and the interval d**1** between adjacent light-emitting portions **50** in the X direction is 0.26 μm. That is, the light-emitting portions **50** are arranged at pitches of 21.16 μm (1200 dpi)

in the X direction. The width W**2** in the Y direction of each light-emitting portion **50** is 20.90 μm, namely, is equal to its width W**1**. The interval d**2** between adjacent light-emitting portions **50** in the Y direction is 0.26 μm, namely, is equal to the interval d**1**. Thus, the light-emitting portions **50** are arranged at pitches of 21.16 μm (1200 dpi) in the Y direction. That is, each light-emitting portion **50** in the present embodiment is shaped as a square of which each side is 20.90 μm, and has an area of 436.81 μm^2. The area accounts for approximately 97.6% of an area of 447.7456 μm^2 that one pixel has. An organic light-emitting material is less in light quantity than an LED. Thus, each light-emitting portion **50** shaped as a square with a small distance between adjacent light-emitting portions **50** as described above enables securement of an area for light emission for acquisition of a level of light quantity enabling a change in the potential of the photoconductive drum **1**.

Note that, desirably, each light-emitting portion **50** has an area that is 90% or more of the area that one pixel occupies. Therefore, for an image forming apparatus A having an output resolution of 1200 dpi, desirably, light-emitting portions **50** are each formed so as to have each side having a width of approximately 20.07 μm or more. For an image forming apparatus A having an output resolution of 2400 dpi, desirably, light-emitting portions **50** are each formed so as to have each side having a width of approximately 10.04 μm or more. The shape of each light-emitting portion **50** is not limited to a square, and may be, for example, an n-gon (n is an integer of 4 or more), a circle, or an ellipse as long as each light-emitting portion **50** emits light covering the size of an exposure region corresponding to the output resolution of the image forming apparatus A and an output image has a level of quality fulfilling the design specification of the image forming apparatus A. The interval d**2** between adjacent light-emitting portions **50** in the Y direction and the number of rows of light-emitting portions **50** in the Y direction are determined, for example, based on the scanning rate of an exposure head **6**, the light quantity required in exposure processing, and resolution.

FIGS. **7**A and **7**B are explanatory schematic views of the irradiated positions of a photoconductive drum **1** with light emitted from two light-emitting portions **50** adjacent in the Y direction. As illustrated in FIG. **7**A, when the two light-emitting portions **50** adjacent in the Y direction light up simultaneously, the irradiated positions of the photoconductive drum **1** with the respective rays of light H emitted from the two light-emitting portions **50** are adjacent in the rotational direction of the photoconductive drum **1** (Y direction, namely, sub-scanning direction) like the positional relationship between the two light-emitting portions **50**. In contrast to this, as illustrated in FIG. **7**B, when the timings at which the two light-emitting portions **50** light up are made different according to the rotational rate of the photoconductive drum **1**, the irradiated positions of the photoconductive drum **1** with the respective rays of light H emitted from the two light-emitting portions **50** can be made substantially the same. As above, irradiating positions substantially the same on the photoconductive drum **1** with light from a plurality of light-emitting portions **50** arranged in the Y direction is referred to as multiple exposure. A larger number of light-emitting portions **50** arranged in the Y direction for use in multiple exposure causes a larger received light quantity at part of the photoconductive drum **1** at the time of multiple exposure.

In order to make the irradiated positions of the photoconductive drum **1** with light emitted from two light-emitting portions **50** adjacent in the Y direction, identical to each other, the timing of lighting of the downstream light-emitting portion **50** in the rotational direction of the photoconductive drum **1** needs delaying by a delay quantity T in time to the timing of lighting of the upstream light-emitting portion **50**. Here, the delay quantity T (s) is calculated by the following Expression 1 with the rotational rate Vdr (mm/s) of the photoconductive drum **1**, the width W**2** (μm) of each of the two light-emitting portions **50** in the Y direction, and the interval d**2** (μm) between the two light-emitting portions **50** in the Y direction.

$$T=((W2+d2)/1000)/Vdr \quad \text{(Expression 1)}$$

In the present embodiment, a signal for light emission is generated such that the maximum value Tw (s) of the duration of light emission of each light-emitting portion **50** is equivalent to the time for one line in the sub-scanning direction. The maximum value Tw (s) is expressed by the following Expression 2 with a resolution of 1200 dpi and the rotational rate Vdr (mm/s) of the photoconductive drum **1**.

$$Tw=(25.4/1200)/Vdr \quad \text{(Expression 2)}$$

<System Configuration of Exposure Head>

Next, the system configuration of the image controller **70** provided on the body side of the image forming apparatus A and an exposure head **6** will be described. Processing for one color from among four colors of yellow, magenta, cyan, and black will be described below. In an image forming operation, for the four colors, similar pieces of processing are performed in parallel.

FIG. **8** is a block diagram of the system configuration of the image controller **70** and an exposure head **6**. As illustrated in FIG. **8**, the image controller **70** includes an image data signal generation portion **71** (image data signal generation portion), a chip data conversion portion **72** (image data signal transmission portion), and a synchronizing signal generation portion **74** (control signal generation portion), in addition to the CPU **73** (controller).

The image controller **70** including the portions described above performs processing of image data and processing of image forming timing and transmits a control signal for control of the exposure head **6** to the printed circuit board **22** of the exposure head **6**. Specifically, the control signal includes an image data signal, a chip select signal, a clock signal, a line synchronizing signal, and a communication signal from the CPU **73**. The signals are transmitted from the image controller **70** to the exposure head **6** through the corresponding signal lines to be described below.

The image data signal generation portion **71** receives image data of an original read by the image reading portion **90** or image data transferred from an external device through a network. The image data signal generation portion **71** performs dithering to the received image data at the resolution based on an instruction from the CPU **73**, and generates an image data signal for output of an image. In the present embodiment, the image data signal generation portion **71** performs dithering at a resolution of 1200 dpi. The image data signal indicates eight levels of gray with the density value ranging from 0 to 7 with a 3-bit width. The density value 0 indicates the minimum density, and the density value 7 indicates the maximum density. Note that the CPU **73** transmits a communication signal for various types of instructions to the image data signal generation portion **71** through a communication signal line **79**.

The synchronizing signal generation portion **74** periodically generates a line synchronizing signal indicating a partition for one line in the main scanning direction of the image data signal. In other words, the synchronizing signal

generation portion **74** periodically generates a line synchronizing signal as a control signal that controls the timing of start of light emission of a light-emitting portion **50** selected according to the image data signal at the time of formation of an electrostatic latent image for one line in the main scanning direction. For image forming in the normal mode, with, as a one-line cycle, the cycle in which the surface of the photoconductive drum **1** moves, in the rotational direction, by the pixel size corresponding to the resolution in the sub-scanning direction to the previously set rotational rate of the photoconductive drum **1**, the CPU **73** gives the synchronizing signal generation portion **74** an instruction for the cycle for a line synchronizing signal. Specifically, in the normal mode, the CPU **73** instructs the synchronizing signal generation portion **74** to generate a line synchronizing signal every time the photoconductive drum **1** rotates by a pitch (approximately 21.16 μm) at a resolution of 1200 dpi. For example, when the photoconductive drum **1** rotates at 200 mm/s in the normal mode, the synchronizing signal generation portion **74** generates a line synchronizing signal at a cycle of 105.8 μs.

As described below, the chip data conversion portion **72** includes a line buffer **15** and receives and stores the image data signal from the image data signal generation portion **71**. Then, in synchronization with the line synchronizing signal input through a line synchronizing signal line **78** after generated by the synchronizing signal generation portion **74** and according to an instruction from the CPU **73**, the chip data conversion portion **72** divides an image data signal for one line for the light-emitting element array chips **40** and transmits the divided image data signals for one line to the light-emitting element array chips **40** through an image data signal line **77**. The chip data conversion portion **72** transmits, to each light-emitting element array chip **40**, a chip select signal indicating the effective range of the image data signal and a clock signal, respectively, through a chip select signal line **75** and a clock signal line **76**.

A head information storage portion **171** included in the exposure head **6** is in connection with the CPU **73** through the communication signal line **79**. The head information storage portion **171** stores, as head information, the quantity of light emission of each light-emitting element array chip **40** and information regarding the mounted location of each light-emitting element array chip **40**. The chip select signal line **75**, the clock signal line **76**, the image data signal line **77**, the line synchronizing signal line **78**, and the communication signal line **79** are each in connection with each light-emitting element array chip **40**. Based on the respective set values of the signals input from the image controller **70** through the signal lines described above, each light-emitting element array chip **40** brings a light-emitting portion **50** into light emission. Each light-emitting element array chip **40** is in cascade-connection with another light-emitting element array chip **40** through the chip select signal line **75**. Each light-emitting element array chip **40** generates a chip select signal to be used in the other light-emitting element array chip **40** and transmits the generated chip select signal to the other light-emitting element array chip **40** through the chip select signal line **75**.

<Chip Data Conversion Portion>

Next, the configuration of the chip data conversion portion **72** will be described.

FIG. **9** is a block diagram of the configuration of the chip data conversion portion **72**. As illustrated in FIG. **9**, the chip data conversion portion **72** includes a buffer write controller **16** and a buffer read controller **17**, in addition to the line buffer **15**. The CPU **73** transmits a control signal to the chip data conversion portion **72**, to control the line buffer **15**, the buffer write controller **16**, and the buffer read controller **17**.

The buffer write controller **16** transmits, to the image data signal generation portion **71**, a notification signal indicating that reception is allowed. Thus, the image data signal generation portion **71** outputs an image data signal. The buffer write controller **16** stores, on a one-line basis, the image data signal output from the image data signal generation portion **71**, into the line buffer **15**. The line buffer **15** has four data storage regions (Buf**000** to Buf**003**), and an image data signal for one line is stored in cycles of Buf**000**, Buf**001**, Buf**002**, and Buf**003**. Every time an image data signal for one line is stored in the line buffer **15**, the buffer write controller **16** transmits, to the buffer read controller **17**, a notification signal indicating write completion. In a case where the data storage regions of the line buffer **15** are full, the buffer write controller **16** stops the transmission of the notification signal indicating that reception is allowed to the image data signal generation portion **71**, to stop the output of the image data signal.

When receiving the notification signal indicating write completion, in synchronization with a line synchronizing signal, the buffer read controller **17** divides an image data signal for one line stored in the line buffer **15** for allocation to the light-emitting element array chips **40** and transmits the divided image data signals for one line together with a clock signal and a chip select signal to the light-emitting element array chips **40**. After transmitting the image data signal for one line to the light-emitting element array chips **40**, the buffer read controller **17** transmits a notification signal indicating read completion to the buffer write controller **16**, to notify the buffer write controller **16** that one of the data storage regions of the line buffer **15** is empty. According to an instruction from the CPU **73**, the buffer read controller **17** can transmit, to the light-emitting element array chips **40**, an image data signal for bringing all the light-emitting portions **50** in the exposure head **6** into non-lighting, instead of transmitting the image data signal stored in the line buffer **15**. The image data signal for bringing all the light-emitting portions **50** in the exposure head **6** into non-lighting has elements that are all "0" or "1".

<System Configuration of Light-Emitting Element Array Chip>

Next, the system configuration of a light-emitting element array chip **40** will be described.

FIG. **10** is a block diagram of the system configuration of a light-emitting element array chip **40**. As illustrated in FIG. **10**, the circuit portion **46** of the light-emitting element array chip **40** includes a digital portion **80** and an analog portion **86**. As described below, the analog portion **86** generates a signal for driving a light-emitting portion **50**, based on a pulse signal generated by the digital portion **80**.

The digital portion **80** includes a communication IF portion **81**, a register portion **82**, a chip select signal generation portion **83**, an image data storage portion **84**, and a pulse signal generation portion **85**. Based on a set value set in advance by the communication signal, the chip select signal, the image data signal, and the line synchronizing signal, in synchronization with the clock signal, the digital portion **80** including the portions generates a pulse signal for bringing a light-emitting portion **50** into light emission and transmits the pulse signal to the analog portion **86**.

Based on the communication signal input from the CPU **73**, the communication IF portion **81** controls write and read of the set value to the register portion **82**. The register portion **82** stores the set value necessary for operation. The set value includes information on the width of a pulse signal

to be generated by the pulse signal generation portion **85**, information on the cycle of the line synchronizing signal, set information on a driving current to be set by the analog portion **86**, and information on the rotational rate of the photoconductive drum **1** in each of the normal mode and the low mode.

The chip select signal generation portion **83** delays the input chip select signal to generate a chip select signal for use in another light-emitting element array chip **40** connected through the chip select signal line **75**. The image data storage portion **84** retains the image data signal while the input chip select signal is valid, and outputs, in synchronization with the line synchronizing signal, the image data signal to a lighting controller **88**.

Based on the cycle of the line synchronizing signal and the information on the width of a pulse signal stored in the register portion **82**, the pulse signal generation portion **85** generates a pulse signal that controls the timing of light emission of a light-emitting portion **50** and outputs the generated pulse signal to the lighting controller **88**. Based on the image data signal output from the image data storage portion **84**, the lighting controller **88** determines, for each light-emitting portion **50**, whether or not the pulse signal generated by the pulse signal generation portion **85** is to be output to the analog portion **86**, and then outputs the pulse signal to the analog portion **86**.

<Image Data Storage Portion>

Next, the configuration of the image data storage portion **84** will be described.

FIG. **11** is a circuit configuration diagram of the image data storage portion **84**. Note that, in FIG. **11**, the image data signal is denoted with "data". The chip select signal and the line synchronizing signal are each a negative logic signal, but may be each a positive logic signal.

As illustrated in FIG. **11**, the image data storage portion **84** includes a clock gate circuit **30** and flip-flop circuits **31** to **37**. The flip-flop circuit **31** (**31-000** to **31-747**) receives, as the original input, the image data signal data input to the image data storage portion **84**, and includes 748 flip-flop circuits connected in series identical in number to the light-emitting portions **50** in the X direction of the light-emitting element array chip **40**.

Similarly, the flip-flop circuits **32** to **37** each include flip-flop circuits identical in number to the light-emitting portions **50** in the X direction of the light-emitting element array chip **40** (**32-000** to **32-747**, **33-000** to **33-747**, **34-000** to **34-747**, **35-000** to **35-747**, **36-000** to **36-747**, and **37-000** to **37-747**).

The clock gate circuit **30** outputs the logical product of the inverted signal of the chip select signal and the clock signal and outputs the clock signal to the flip-flop circuit **31** only when the chip select signal is valid. The flip-flop circuit **31** operates due to the clock signal sent from the clock gate circuit **30** and outputs the image data signal (dly_data_**000**).

With the output of the flip-flop circuit **31-000** as an input, the flip-flop circuit **32-000** operates due to the line synchronizing signal. The output (buf_data_**0**_**000**) of the flip-flop circuit **32-000** is input to the flip-flop circuit **33-000** and the lighting controller **88**.

With the output of the flip-flop circuit **32-000** as an input, the flip-flop circuit **33-000** operates due to the line synchronizing signal. The output (buf_data_**1**_**000**) of the flip-flop circuit **33-000** is input to the flip-flop circuit **34-000** and the lighting controller **88**.

With the output of the flip-flop circuit **33-000** as an input, the flip-flop circuit **34-000** operates due to the line synchronizing signal. The output (buf_data_**2**_**000**) of the flip-flop circuit **34-000** is input to the flip-flop circuit **35-000** and the lighting controller **88**.

With the output of the flip-flop circuit **34-000** as an input, the flip-flop circuit **35-000** operates due to the line synchronizing signal. The output (buf_data_**3**_**000**) of the flip-flop circuit **35-000** is input to the flip-flop circuit **36-000** and the lighting controller **88**.

With the output of the flip-flop circuit **35-000** as an input, the flip-flop circuit **36-000** operates due to the line synchronizing signal. The output (buf_data_**4**_**000**) of the flip-flop circuit **36-000** is input to the flip-flop circuit **37-000** and the lighting controller **88**.

With the output of the flip-flop circuit **36-000** as an input, the flip-flop circuit **37-000** operates due to the line synchronizing signal. The output (buf_data_**5**_**000**) of the flip-flop circuit **37-000** is input to the lighting controller **88**.

Note that the flip-flop circuits **32-001** to **32-747**, **33-001** to **33-747**, **34-001** to **34-747**, **35-001** to **35-747**, **36-001** to **36-747**, and **37-001** to **37-747** operate similarly to the flip-flop circuits **32-000** to **37-000** described above.

FIG. **12** is a timing chart of the operation in the main scanning direction of the image data storage portion **84**. Reference signs in FIG. **12** are the same as those in FIG. **11** in meaning. As illustrated in FIG. **12**, from time T**0** at which the chip select signal has a low output at a rise in the clock signal to time T**1**, the image data signal shifts, for example, in the order from data to dly_data_**000** to dly_data_**001**. The low output of the chip select signal is input so as to cover **748** pulses in the clock signal identical in number to the light-emitting portions **50** in the main scanning direction. Thus, an image data signal for one line is retained as dly_data_**000** to dly_data_**747**.

Because the chip select signal is high after time T**1**, retention is performed with no shift operation. At time T**2** at which the line synchronizing signal has a low output at a rise in the clock signal, the image data signal for one line shifts at a time as buf_data_**0**_**000** to buf_data_**0**_**747**, for example, from dly_data_**000** to buf_data_**0**_**000** and from dly_data_**001** to buf_data_**0**_**001** and then is output to the lighting controller **88**.

FIG. **13** is a timing chart of the operation in the sub-scanning direction of the image data storage portion **84** in the normal mode. Reference signs in FIG. **13** are the same as those in FIG. **11** in meaning. The outputs buf_data_**0**_**000**, buf_data_**1**_**000**, buf_data_**2**_**000**, buf_data_**3**_**000**, buf_data_**4**_**000**, and buf_data_**5**_**000** of the flip-flop circuits **32-000**, **33-000**, **34-000**, **35-000**, **36-000**, and **37-000** illustrated in FIG. **11** will be described below. The same applies to buf_data_**0**_**001** to buf_data_**0**_**747**, buf_data_**1**_**001** to buf_data_**1**_**747**, buf_data_**2**_**001** to buf_data_**2**_**747**, buf_data_**3**_**001** to buf_data_**3**_**747**, buf_data_**4**_**001** to buf_data_**4**_**747**, and buf_data_**5**_**001** to buf_data_**5**_**747** about which no description will be given below.

As illustrated in FIG. **13**, every rise from low to high in the line synchronizing signal, a shift is made, for example, from dly_data_**000** to buf_data_**0**_**000** or from buf_data_**0**_**000** to buf_data_**1**_**000**. Thus, the value of B**000** in dly_data_**000** at time S**0** is output, for example, as buf_data_**0**_**000** at time S**1**, buf_data_**1**_**000** at time S**2**, and buf_data_**2**_**000** at time S**3**, to the lighting controller **88**.

As above, the first light-emitting portion **50** to the last light-emitting portion **50** for exposure on the photoconductive drum **1** are connected, respectively, to buf_data_**0**_**000**,

buf_data_1_000, buf_data_2_000, buf_data_3_000, buf_data_4_000, and buf_data_5_000, enabling achievement of multiple exposure.

<Analog Portion>

Next, the configuration of the analog portion **86** will be described. Note that, in the following description, two drive portions **61** that drive, respectively, two light-emitting portions **50** will be given. Similarly, all the light-emitting portions **50** are driven one-to-one by similar drive portions **61**.

FIG. **14** is a block diagram of the configuration of the analog portion **86**. As illustrated in FIG. **14**, the analog portion **86** includes a drive portion **61** that drives a light-emitting portion **50**, a DAC **62** serving as a digital/analog converter, and a drive-portion selection portion **67**.

Based on the data set in the register portion **82**, the DAC **62** supplies, through a signal line **63**, the drive portion **61** with an analog voltage that determines a drive current. The pulse signal output from the lighting controller **88** is input to the drive portion **61** through a signal line **66**. As above, the drive portion **61** receives the analog voltage that determines a drive current and the pulse signal. Then, based on the signals, the drive portion **61** controls the drive current to the light-emitting portion **50** and the duration of light emission of the light-emitting portion **50**, with a drive circuit to be described below.

Based on the data set in the register portion **82**, the drive-portion selection portion **67** supplies two drive portions **61** with a drive-portion select signal that selects a drive portion **61** through signal lines **64** and **65**. Here, a high drive-portion select signal is generated to a drive portion **61** to be selected. For example, in order to select the upper drive portion **61** illustrated in FIG. **14**, a high drive-portion select signal is supplied to only the signal line **64** and a low drive-portion select signal is supplied to the signal line **65**. At the timing at which the drive-portion select signal becomes high to each of the two drive portions **61**, the DAC **62** sets, to each of the two drive portions **61**, an analog voltage that determines a drive current. As above, the CPU **73** successively selects a drive portion **61** through the register portion **82** and sets an analog voltage to the selected drive portion **61**, so that analog voltages are set to all the drive portions **61** with a single DAC **62**.

<Drive Portion>

Next, the configuration of a drive portion **61** will be described.

FIG. **15** is a circuit diagram of a drive portion **61**. As illustrated in FIG. **15**, the drive portion **61** includes MOSFETs **112** to **115**, a capacitor **116**, and an inverter **117**.

According to a value of gate voltage, the MOSFET **112** supplies a drive current to the light-emitting portion **50**. When the gate voltage is low in level, the MOSFET **112** controls the drive current to be off (non-lighting). The MOSFET **114** has its gate to which the signal line **66** is connected. When the pulse signal input through the signal line **66** is high, the MOSFET **114** transfers, to the MOSFET **112**, the voltage charged in the capacitor **116**.

The MOSFET **115** has its gate to which the signal line **64** is connected for reception of the drive-portion select signal transmitted from the drive-portion selection portion **67**. In response to input of a high drive-portion select signal, the MOSFET **115** switches on, so that the capacitor **116** is charged with the analog voltage transmitted through the signal line **63** after output from the DAC **62**. In the present embodiment, the DAC **62** sets an analog voltage to the capacitor **116** at the timing before image forming, and keeps the MOSFET **115** off during image forming operation, leading to retention of the voltage level.

Due to the above operation, the MOSFET **112** supplies a drive current to the light-emitting portion **50**, according to the set analog voltage and the pulse signal. In a case where the light-emitting portion **50** has a large input capacitance and a low response rate for turning off, the MOSFET **113** can make an increase in the response rate for turning off. The MOSFET **113** has its gate to which the pulse signal logic-inverted by the inverter **117** is input. A low pulse signal brings the gate of the MOSFET **113** high, leading to forcible discharge of the electric charges charged in the input capacitance of the light-emitting portion **50**.

<Control of Light-Emitting Portion in Low Mode>

As described above, the CPU **73** can perform the normal mode or the low mode at the time of image forming, and changes the rotational rate of the photoconductive drum **1** at the time of a switch between the modes. Here, in a case where, in the low mode similarly to in the normal mode, the CPU **73** controls the synchronizing signal generation portion **74** with the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction, as the cycle of the line synchronizing signal, the following problem occurs.

That is, a reduction in the rotational rate of the photoconductive drum **1** lengthens the cycle of the line synchronizing signal, causing a large quantity of light to be emitted to the region corresponding to one pixel on the photoconductive drum **1**. For example, in a case where the rotational rate of the photoconductive drum **1** in the low mode is half of that in the normal mode, the cycle of the line synchronizing signal in the low mode is two times that in the normal mode, so that the quantity of light to be emitted to the region corresponding to one pixel on the photoconductive drum **1** in the low mode is two times that in the normal mode. In a case where a large quantity of light is emitted to the region corresponding to one pixel on the photoconductive drum **1**, excessive toner adheres on the photoconductive drum **1** in developing an electrostatic latent image.

In order to inhibit excessive toner from adhering on the photoconductive drum **1**, it can be thought that a reduction is made in light quantity with the value of current for driving a light-emitting portion **50** lower in the low mode than in the normal mode. However, a sophisticated circuit is required to drive a light-emitting portion **50** variable in light quantity. Thus, the CPU **73** performs the following control in the low mode to inhibit excessive toner from adhering on the photoconductive drum **1** with a reduction in the quantity of light to be emitted to the region corresponding to one pixel on the photoconductive drum **1**.

FIG. **16** is a timing chart of the operation in the sub-scanning direction of the image data storage portion **84** in the low mode. Herein, for example, the rotational rate of the photoconductive drum **1** in the low mode is ⅔ times the rotational rate of the photoconductive drum **1** in the normal mode. Note that reference signs in FIG. **16** are the same as those in FIG. **11** in meaning.

As illustrated in FIG. **16**, the CPU **73** instructs the synchronizing signal generation portion **74** to make the cycle of the line synchronizing signal in the low mode ½ times the cycle of the line synchronizing signal in the normal mode. The numerical value "½" is determined as follows. That is, for example, the rotational rate of the photoconductive drum **1** in the low mode is m/n times the rotational rate of the photoconductive drum **1** in the normal mode. Note that, since the rotational rate of the photoconductive drum **1** is lower in the low mode than in the normal mode, the

following expression is satisfied: m<n. In this case, the CPU **73** acquires a value n/m (reciprocal of m/n) times the cycle of the line synchronizing signal in the normal mode. The value acquired here corresponds to the time during which the photoconductive drum **1** moves in the rotational direction by the pixel size corresponding to the resolution in the sub-scanning direction in the low mode.

Next, the CPU **73** further acquires a value 1/n times the acquired value n/m times the cycle of the line synchronizing signal in the normal mode. The CPU **73** instructs the synchronizing signal generation portion **74** to set the value acquired in this manner as the cycle of the line synchronizing signal. Note that the cycle of the line synchronizing signal in the low mode acquired in this manner can be regarded as the time resulting from dividing, by n, the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction in the low mode.

That is, in the low mode in which the photoconductive drum **1** rotates at a rate m/n times the rotational rate in the normal mode, lower than the rotational rate in the normal mode (first rotational rate) (second rotational rate), the CPU **73** controls the synchronizing signal generation portion **74** as follows. That is, in the low mode, the CPU **73** causes the synchronizing signal generation portion **74** to generate a line synchronizing signal at a cycle 1/m times the cycle of the line synchronizing signal generated in the normal mode.

Next, the CPU **73** controls the chip data conversion portion **72** as follows. That is, the CPU **73** causes the buffer read controller **17** to read an image data signal for one line from Buf**000** in the line buffer **15** and transmit the image data signal for one line to the light-emitting element array chips **40**, in synchronization with the first line synchronizing signal and the second line synchronizing signal from among three line synchronizing signals generated in the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction in the low mode. That is, in synchronization with the first line synchronizing signal generated at time S**0**A and the second line synchronizing signal generated at time SOB, the buffer read controller **17** transmits, to the light-emitting element array chips **40**, the same image data signal for one line.

Next, the CPU **73** causes the buffer read controller **17** to transmit an image data signal that brings the light-emitting portions **50** into no light emission (non-lighting) to each light-emitting element array chip **40**, in synchronization with the third line synchronizing signal generated at time SOC. Thus, in synchronization with the three line synchronizing signals, the buffer read controller **17** transmits the same image data signal for one line twice and the image data signal that brings the light-emitting portions **50** into no light emission one time as three image data signals to be transmitted to the exposure head **6**. Generalization of the number of times of transmission of each image data signal by the buffer read controller **17** with n and m described above leads to as follows. That is, the CPU **73** causes the buffer read controller **17** to output the same image data signal for one line m times and output the image data signal that brings the light-emitting portions **50** into no light emission n-m times, in synchronization with n number of line synchronizing signals generated in the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction in the low mode. In other words, the CPU **73** controls the chip data conversion portion **72** as above for exposure for forming an image for one line extending in the main scanning direction (rotational-axis direction of the photoconductive drum **1** or width direction of a sheet S) onto a sheet S.

Here, the duration of light emission of each light-emitting portion **50** due to two times of transmission of the same image data signal for one line to each light-emitting element array chip **40** by the chip data conversion portion **72** is equal to the duration of light emission of each light-emitting portion **50** in the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction in the normal mode. That is, the period from time S**0**A to time SOB illustrated in FIG. **16** is equal to the period from time S**0** to time S**1** illustrated in FIG. **13**. The period from time S**0**A to time SOB illustrated in FIG. **16** corresponds to the time during which the photoconductive drum **1** rotates by the pixel size corresponding to the resolution in the sub-scanning direction in the low mode. The same applies to the other times. Thus, in the low mode, the CPU **73** controls the chip data conversion portion **72** and the synchronizing signal generation portion **74** as above, so that the quantity of light to be emitted to the region corresponding to one pixel on the photoconductive drum **1** can be kept constant between in the normal mode and in the low mode.

Note that the CPU **73** instructs the buffer read controller **17** to transmit a notification signal indicating read completion to the buffer write controller **16** after the buffer read controller **17** transmits the image data signal to the exposure head **6** in synchronization with the second line synchronizing signal. When receiving the notification signal indicating read completion, the buffer write controller **16** generates a notification signal indicating that reception is allowed and outputs, to the image data signal generation portion **71**, the generated notification signal indicating that reception is allowed. When receiving the notification signal indicating that reception is allowed, the image data signal generation portion **71** transmits the next image data signal for one line to the buffer write controller **16**. The buffer write controller **16** stores, into Buf**000** empty in the line buffer **15**, the next image data signal for one line received from the image data signal generation portion **71**. The CPU **73** instructs the buffer read controller **17** to read the image data signal from Buf**001** and transmit the read image data signal to the printed circuit board **22**, in synchronization with the line synchronizing signal generated at time S**1**A. The CPU **73** repeatedly performs the above control after time S**1**B for exposure processing.

In summary, in the low mode in which the photoconductive drum **1** rotates at a rate m/n times the rotational rate in the normal mode, lower than the rotational rate in the normal mode, the CPU **73** performs the following control. That is, in the low mode, the CPU **73** causes the synchronizing signal generation portion **74** to generate a line synchronizing signal at a cycle 1/m times the cycle of the line synchronizing signal generated in the normal mode. For exposure for forming an image for one line extending in the main scanning direction onto a sheet S, the CPU **73** causes the buffer read controller **17** to transmit the same image data signal m times and transmit the image data signal that brings the light-emitting portions **50** into no light emission n-m times, in synchronization with n number of line synchronizing signals generated by the synchronizing signal generation portion **74**. Thus, the quantity of light to be emitted to the region corresponding to one pixel on the photoconductive drum **1** can be kept constant between in the normal mode and in the low mode. Therefore, in the low mode, excessive toner can be inhibited from adhering on the photoconductive drum **1**.

Note that, in the above description, the rotational rate of the photoconductive drum **1** in the low mode is ⅔ times that in the normal mode, but this is not limiting. That is, the difference in rate between the normal mode and the low mode is not limited to the above, and thus a similar effect can be acquired even with any difference in rate.

In the present embodiment, in order to cover a shortage of light quantity per light-emitting portion **50**, multiple exposure is performed with a plurality of light-emitting portions **50** arranged in the Y direction, but this is not limiting. That is, in a case where no multiple exposure with light-emitting portions **50** arranged in the Y direction is required due to a high light quantity per light-emitting portion **50**, even the above control with a single row of a plurality of light-emitting portions **50** arranged in the X direction enables acquisition of a similar effect.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all modifications, equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2021-100144, filed Jun. 16, 2021, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An image forming apparatus comprising:

a photoconductive drum;

an exposure head including a plurality of light-emitting portions arranged along in a rotational-axis direction of the photoconductive drum, the plurality of light-emitting portions each being configured to emit light, based on an image data signal, for exposure of the photoconductive drum;

a control signal generation portion configured to generate, at a predetermined cycle, a control signal that controls a timing of light emission of each of the plurality of light-emitting portions;

an image data signal transmission portion configured to transmit the image data signal to the exposure head, in synchronization with the control signal, for light emission of each of the plurality of light-emitting portions based on the image data signal; and

a controller configured to control the control signal generation portion, the image data signal transmission portion, and a rotational rate of the photoconductive drum, wherein

the controller is configured to perform in a first mode in which the photoconductive drum rotates at a first rotational rate and a second mode in which the photoconductive drum rotates at a second rotational rate m/n times the first rotational rate, and lower than the first rotational rate, and

in the second mode, for exposure for forming an image for one line onto a sheet, the controller causes the control signal generation portion to generate the control signal at a cycle 1/m times a cycle of the control signal generated in the first mode, and causes the image data signal transmission portion to transmit, to the exposure head, the same image data signal m times and transmit, to the exposure head, the image data signal that brings the plurality of light-emitting portions into no light emission n-m times, in synchronization with n number of the control signals.

2. The image forming apparatus according to claim **1**, wherein in the second mode, for the exposure for forming an image for one line onto a sheet, the controller causes the image data signal transmission portion to transmit, to the exposure head, the image data signal that brings the plurality of light-emitting portions into no light emission n-m times after the image data signal transmission portion transmits, to the exposure head, the same image data signal m times, in synchronization with the n number of the control signals.

3. The image forming apparatus according to claim **1**, further comprising:

a developing portion configured to develop, as a toner image, an electrostatic latent image formed on a surface of the photoconductive drum by the exposure head;

a transfer portion configured to transfer, to a sheet, the toner image formed on the surface of the photoconductive drum; and

a fixing portion configured to fix, to the sheet, the toner image transferred to the sheet, wherein the controller:

controls, based on information regarding a basis weight of a sheet for image forming, a conveyance rate of the sheet that passes through the fixing portion,

performs in the first mode in a case where the conveyance rate of the sheet that passes through the fixing portion is a first conveyance rate, and

performs in the second mode in a case where the conveyance rate of the sheet that passes through the fixing portion is a second conveyance rate lower than the first conveyance rate.

4. The image forming apparatus according to claim **1**, wherein

the plurality of light-emitting portions is provided in the exposure head such that a plurality of light-emitting rows is formed of the plurality of light-emitting portions arranged in the rotational-axis direction and the plurality of light-emitting rows is arranged in a direction orthogonal to the rotational-axis direction, and

the exposure head performs multiple exposure to a region corresponding to one pixel on a surface of the photoconductive drum with the light-emitting portion in each of the plurality of light-emitting rows.

5. The image forming apparatus according to claim **4**, wherein each of the plurality of light-emitting portions includes a first electrode layer including a plurality of electrodes arranged two-dimensionally in the rotational-axis direction and in the direction orthogonal to the rotational-axis direction, the plurality of electrodes being disposed separately from each other on a substrate; a light-emitting layer stacked on the first electrode layer, the light-emitting layer being configured to emit light due to application of voltage; and a second electrode layer disposed opposite the first electrode layer through the light-emitting layer, the second electrode layer allowing light to pass through the second electrode layer.

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